

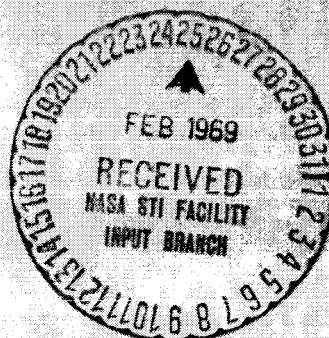
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**FORTTRAN PROGRAMS FOR CALCULATING  
WIND-TUNNEL BOUNDARY INTERFERENCE**

*by Harry H. Heyson*

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FORTAN PROGRAMS FOR CALCULATING WIND-TUNNEL  
BOUNDARY INTERFERENCE

By Harry H. Heyson

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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# FORTTRAN PROGRAMS FOR CALCULATING WIND-TUNNEL BOUNDARY INTERFERENCE

By Harry H. Heyson  
Langley Research Center

## SUMMARY

Boundary-interference programs, developed in NASA TR R-302, are presented without comment. These programs should be utilized only after careful consideration of the assumptions and procedures given in that report.

## INTRODUCTION

Reference 1 develops a systematic computer procedure for calculating the wind-tunnel interference factors for arbitrary configurations from the interference calculations for a vanishingly small model. The method is not limited to any one tunnel configuration since it is necessary only to substitute a subroutine appropriate to the tunnel for that given herein.

The underlying theory (subroutine DLTAS) in the present computer programs is that of reference 2. It is directly applicable to models which produce large wake deflections, such as V/STOL models. These programs may also be used directly for more conventional testing at moderate lift coefficients by means of the few simple modifications described in reference 1.

No sample calculations or check cases are provided herewith. The numerical values provided in reference 1 should be adequate for this purpose. The reader is cautioned against using these programs without first carefully considering the assumptions, limitations, and procedures given in reference 1.

## COMPUTER PROGRAMS

The programs are given in the appendixes. The following table should aid in locating the program of interest:

Appendix	Model	Interference	Page
A	Small	At point	4
B	Wing	Average	6
C	Wing	Span distribution	9
D	Wing	At tail	12
E	Jet	At wing	16
F	Jet	Wing distribution	20
G	Jet	At tail	24
H	Rotor	Average	28
I	Rotor	Lateral axis	31
J	Rotor	Longitudinal axis	34
K	Rotor	At tail	37
L	Tandem rotors	Average	41
M	Unloaded rotors	Average	46
N	Unloaded rotors	At tail	52
O	Side-by-side rotors	Average	57
P	Side-by-side rotors	At tail	64
Q	Subroutine DLTAS		70

Langley Research Center,  
National Aeronautics and Space Administration,  
Langley Station, Hampton, Va., December 11, 1968,  
721-01-00-20-23.

## REFERENCES

1. Heyson, Harry H.: Use of Superposition in Digital Computers to Obtain Wind-Tunnel Interference Factors for Arbitrary Configurations, With Particular Reference to V/STOL Models. NASA TR R-302, 1969.
2. Heyson, Harry H.: Linearized Theory of Wind-Tunnel Jet-Boundary Corrections and Ground Effect for VTOL-STOL Models. NASA TR R-124, 1962.

# APPENDIX A

## FORTRAN PROGRAM FOR CALCULATING WIND-TUNNEL INTERFERENCE NEAR A VANISHINGLY SMALL MODEL

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

THIS IS THE BASIC WIND-TUNNEL INTERFERENCE PROGRAM FOR WHICH THE DERIVATIONS ARE GIVEN IN NASA TR R-124 (REF 2). THE SUCCEEDING PROGRAMS ARE ALL DEVELOPED FROM THIS ONE PROGRAM. INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. THE REQUIRED INPUT VARIABLES ARE

ZETA	SEMIHEIGHT OF WIND TUNNEL DIVIDED BY HEIGHT OF MODEL ABOVE FLOOR
ETA	DISTANCE FROM MODEL TO RIGHT-HAND WALL DIVIDED BY WIND-TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
XOVERH	LONGITUDINAL POSITION OF POINT AT WHICH INTERFERENCE IS NEEDED, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
YOVERH	LATERAL POSITION OF POINT AT WHICH INTERFERENCE IS NEEDED, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
ZOVERH	VERTICAL POSITION OF POINT AT WHICH INTERFERENCE IS NEEDED, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT

```

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)          (A 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)             (A 2)
DIMENSION C(8)                                                    (A 3)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./             (A 4)
1 READ (5,103) ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH               (A 5)
IF (EOF,5) 999,2                                                  (A 6)
2 WRITE (6,148) GAMMA,ZETA,ETA,XOVERH,YOVERH,ZOVERH              (A 7)
WRITE (6,210)                                                       (A 8)
WRITE (6,211)                                                       (A 9)
WRITE (6,212)                                                       (A 10)
WRITE (6,213)                                                       (A 11)
WRITE (6,214)                                                       (A 12)
WRITE (6,215)                                                       (A 13)
WRITE (6,216)                                                       (A 14)
WRITE (6,217)                                                       (A 15)

```

# Appendix A - Concluded

```

WRITE (6,218) (A 16)
DO 41 K=1,8 (A 17)
CALL DLTAS (C(K)) (A 18)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
WRITE (6,149) C(K) (A 19)
WRITE (6,150) (DELTA(I),I=1,25,4) (A 20)
WRITE (6,151) (DELTA(I),I=2,26,4) (A 21)
WRITE (6,152) (DELTA(I),I=3,27,4) (A 22)
WRITE (6,153) (DELTA(I),I=4,28,4) (A 23)
41 CONTINUE (A 24)
GO TO 1 (A 25)
103 FORMAT (6F10.3) (A 26)
148 FORMAT (1H1//35X*INTERFERENCE FACTORS AT A POINT NEAR A VANISHINGL (A 27)
1Y SMALL MODEL*//35X*GAMMA =*F8.3,9X*ZETA =*F8.3,11X*ETA =* (A 28)
2F8.3//35X*X/H =*F8.3,9X*Y/H =*F8.3,11X*Z/H =*F8.3//) (A 29)
149 FORMAT ( /5X6H CHI =F6.2/) (A 30)
150 FORMAT (3X5H(W,L)7(F17.4)) (A 31)
151 FORMAT (3X5H(U,L)7(F17.4)) (A 32)
152 FORMAT (3X5H(W,D)7(F17.4)) (A 33)
153 FORMAT (3X5H(U,D)7(F17.4)/) (A 34)
210 FORMAT (1X131(1H-)) (A 35)
211 FORMAT (1X1HI11X1HI31X61H CORRECTION FACTORS FOR CORRECTING FROM A (A 36)
1WIND TUNNEL WHICH IS25X1HI) (A 37)
212 FORMAT (1X1HI11X1HI117(1H-)1HI) (A 38)
213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (A 39)
1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI) (A 40)
214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (A 41)
1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X5HCLOSED5X1HI3X9HON BOTTOM3X1H (A 42)
2I) (A 43)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI (GRCUND EFFECT) I6X4H (A 44)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (A 45)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (A 46)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1 (A 47)
1HI) (A 48)
218 FORMAT (1X131(1H-)/) (A 49)
999 STOP (A 50)
END (A 51)

```

# APPENDIX B

## FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A SWEEP WING

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE APEX OF THE SWEEP LIFTING LINE. THE REQUIRED INPUT VARIABLES ARE

LI            LOAD INDICATOR, LI=1 FOR UNIFORM LOADING, L=2 FOR ELLIPTIC LOADING

ZETA1        SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR

ETA1        DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH

GAMMA       WIDTH-HEIGHT RATIO OF WIND TUNNEL

SIGMA       RATIO OF WING SPAN TO TUNNEL WIDTH

LAMBDA      WING SWEEP ANGLE, DEG

ALPHA       ANGLE OF ATTACK OF WING, DEG

```

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)      (B 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)         (B 2)
DIMENSION XDDELTA(28),XLOAD(10),XLE(10),C(8)                (B 3)
REAL LAMBDA                                                    (B 4)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./          (B 5)
XLE(1)=XLE(10)=0.43579                                         (B 6)
XLE(2)=XLE(9)=0.71422                                          (B 7)
XLE(3)=XLE(8)=0.86603                                          (B 8)
XLE(4)=XLE(7)=0.95394                                          (B 9)
XLE(5)=XLE(6)=0.99499                                          (B 10)
DO 803 LI=1,28                                                 (B 11)
803 XDDELTA(LI)=0.                                             (B 12)
PI=3.14159265358979                                           (B 13)
RAD=.0174532925199                                             (B 14)
1 READ (5,900) LI,ZETA1,ETA1,GAMMA,SIGMA,LAMBDA,ALPHA        (B 15)
IF (EOF,5) 999,47                                              (B 16)

```



# Appendix B - Continued

```

47 IF (LI.EQ.1) GO TO 804 (B 17)
   IALPHA=8HELLIPTIC (B 18)
   SUML=0.0126104 (B 19)
   DO 808 M2=1,10 (B 20)
808 XLOAD(M2)=XLE(M2) (B 21)
   GO TO 160 (B 22)
804 SUML=0.01 (B 23)
   IALPHA=8HUNIFORM (B 24)
   DO 809 M2=1,10 (B 25)
809 XLOAD(M2)=1.0 (B 26)
160 WRITE (6,901) IALPHA,GAMMA,ETA1,SIGMA,ZETA1,ALPHA,LAMBDA (B 27)
   WRITE (6,210) (B 28)
   WRITE (6,211) (B 29)
   WRITE (6,212) (B 30)
   WRITE (6,213) (B 31)
   WRITE (6,214) (B 32)
   WRITE (6,215) (B 33)
   WRITE (6,216) (B 34)
   WRITE (6,217) (B 35)
   WRITE (6,218) (B 36)
   CONST1=1. (B 37)
   LAMBDA=LAMBDA*RAD (B 38)
   ALPHA=ALPHA*RAD (B 39)
   DO 41 K=1,8 (B 40)
   IF (SIGMA.NE.0.) GO TO 811 (B 41)
   M6=M7=N6=N7=1 (B 42)
   XLOAD(1)=1.0 (B 43)
   SUML=1. (B 44)
   GO TO 812 (B 45)
811 IF (ETA1.NE.1.) GO TO 813 (B 46)
   N6=1 (B 47)
   M6=6 (B 48)
   N7=M7=10 (B 49)
   CONST1=2. (B 50)
   GO TO 812 (B 51)
813 M6=N6=1 (B 52)
   M7=N7=10 (B 53)
812 DO 801 M1=M6,M7 (B 54)
   DO 802 N1=N6,N7 (B 55)
   XSTAR=(11.-2.*FLOAT(M1))/10. (B 56)
   YSTAR=(2.*FLOAT(N1)-11.)/10. (B 57)
   ZSTAR=(11.-2.*FLOAT(N1))/10. (B 58)
   ETA=ETA1+YSTAR*SIGMA (B 59)
   ZETA=ZETA1/(1.-ABS(YSTAR)*SIGMA*GAMMA*ZETA1*TAN(LAMBDA)*SIN(ALPHA) (B 60)
1) (B 61)
   XOVERH=SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)*(ABS(XSTAR)-ABS(ZSTAR)) (B 62)
   YOVERH=(FLOAT(M1)-FLOAT(N1))*SIGMA*GAMMA*(-.2) (B 63)
   ZOVERH=SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)*(ABS(ZSTAR)-ABS(XSTAR)) (B 64)
   CALL DLTAS (C(K)) (B 65)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
   DO 805 L1=1,28 (B 66)
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1) (B 67)
802 CONTINUE (B 68)
801 CONTINUE (B 69)
   DO 807 L3=1,28 (B 70)
807 DELTA(L3)=XDELTA(L3)*SUML*CONST1 (B 71)
   WRITE (6,149) C(K) (B 72)
   WRITE (6,150) (DELTA(I),I=1,25,4) (B 73)
   WRITE (6,151) (DELTA(I),I=2,26,4) (B 74)
   WRITE (6,152) (DELTA(I),I=3,27,4) (B 75)
   WRITE (6,153) (DELTA(I),I=4,28,4) (B 76)

```

# Appendix B - Concluded

```

      DD 814 L4=1,28 (B 77)
814 XDELTA(L4)=0. (B 78)
      41 CONTINUE (B 79)
      GO TO 1 (B 80)
149 FORMAT (1X*CHI =*F7.3/) (B 81)
150 FORMAT (3X5H(W,L)7(F17.4)) (B 82)
151 FORMAT (3X5H(U,L)7(F17.4)) (B 83)
152 FORMAT (3X5H(W,D)7(F17.4)) (B 84)
153 FORMAT (3X5H(U,D)7(F17.4)//) (B 85)
210 FORMAT (1X131(1H-)) (B 86)
211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A (B 87)
      1WIND TUNNEL WHICH IS25X1HI) (B 88)
212 FORMAT (1X1HI11X1HI117(1H-)1HI) (B 89)
213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLJOR2X1 (B 90)
      1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI) (B 91)
214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (B 92)
      1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (B 93)
      2I) (B 94)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 16X4H (B 95)
      1ONLY6X1HI16X1HI6X4HONLY5X1HI) (B 96)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (B 97)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (B 98)
      1HI) (B 99)
218 FORMAT (1X131(1H-)) (B 100)
900 FORMAT (11,F9.3,5F10.3) (B 101)
901 FORMAT (1HI///42X*AVERAGE INTERFERENCE OF SWEEP WING OF FINITE SPA (B 102)
      1N**58XA8,* LOADING**36X*GAMMA =*F6.3,10X*ETA =*F7.3,10X (B 103)
      2*SIGMA =*F7.3//36X*ZETA =*F6.3,10X*ALPHA =*F7.3,10X (B 104)
      3*LABDA =*F7.3//) (B 105)
999 STOP (B 106)
      END (B 107)

```

## APPENDIX C

### FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF WIND-TUNNEL INTERFERENCE OVER THE SPAN OF A SWEEP WING

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 5000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE APEX OF THE SWEEP LIFTING LINE. THE REQUIRED INPUT VARIABLES ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM LOADING, L=2 FOR ELLIPTIC LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG
ALPHA	ANGLE OF ATTACK OF WING, DEG
C	EFFECTIVE WAKE SKEW-ANGLE, DEG

IN SYMMETRICAL CASES THIS PROGRAM COMPUTES THE INTERFERENCE DISTRIBUTION OVER ONE SEMISPAN ONLY. THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PROVIDED BY THE PROGRAM OF APPENDIX B.

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)	(C 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)	(C 2)
DIMENSION XDELTA(28),XLOAD(10),XLE(10)	(C 3)
REAL LAMBDA	(C 4)
XLE(1)=XLE(10)=.43579	(C 5)
XLE(2)=XLE(9)=.71422	(C 6)

# Appendix C - Continued

```

XLE(3)=XLE(8)=.86603 (C 7)
XLE(4)=XLE(7)=.95394 (C 8)
XLE(5)=XLE(6)=.99499 (C 9)
DO 805 N2=1,28 (C 10)
805 XDELTA(N2)=0. (C 11)
RAD=.0174532925199 (C 12)
1 READ (5,103) LI,ZETA1,ETA1,GAMMA,SIGMA,LAMBDA,ALPHA,C (C 13)
IF (EOF,5) 999,814 (C 14)
814 IF (LI.EQ.1) GO TO 806 (C 15)
IALPHA=8FELLIPTIC (C 16)
SUML=.126104 (C 17)
DO 808 M2=1,10 (C 18)
808 XLOAD(M2)=XLE(M2) (C 19)
GO TO 803 (C 20)
806 SUML=.1 (C 21)
IALPHA=8HUNIFORM (C 22)
DO 809 M2=1,10 (C 23)
809 XLOAD(M2)=1.0 (C 24)
803 XOVERH=ZOVERH=0. (C 25)
M1=0 (C 26)
IF (ETA1.EQ.1.) M1=6 (C 27)
WRITE (6,900) GAMMA,ZETA1,IALPHA,ALPHA,SIGMA,ETA1,LAMBDA,C (C 28)
WRITE (6,210) (C 29)
WRITE (6,211) (C 30)
WRITE (6,212) (C 31)
WRITE (6,213) (C 32)
WRITE (6,214) (C 33)
WRITE (6,215) (C 34)
WRITE (6,216) (C 35)
WRITE (6,217) (C 36)
WRITE (6,218) (C 37)
IF (SIGMA.NE.0.) GO TO 813 (C 38)
WRITE (6,901) (C 39)
GO TO 1 (C 40)
813 ALPHA=ALPHA*RAD (C 41)
LAMBDA=LAMBDA*RAD (C 42)
804 XSTAR=(11.-2.*FLOAT(M1))/10. (C 43)
DO 800 N1=1,10 (C 44)
YSTAR=(2.*FLOAT(N1)-11.)/10. (C 45)
ZSTAR=(11.-2.*FLOAT(N1))/10. (C 46)
ETA=ETA1+YSTAR*SIGMA (C 47)
ZETA=ZETA1/(1.-ABS(YSTAR)*SIGMA*GAMMA*ZETA1*TAN(LAMBDA)*SIN(ALPHA) (C 48)
1) (C 49)
XOVERH=SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)*(ABS(XSTAR)-ABS(ZSTAR)) (C 50)
YOVERH=(FLOAT(M1)-FLOAT(N1))*SIGMA*GAMMA*(-.2) (C 51)
ZOVERH=SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)*(ABS(ZSTAR)-ABS(XSTAR)) (C 52)
CALL DLTAS (C) (C 53)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
DO 801 N2=1,28 (C 54)
801 XDELTA(N2)=XDELTA(N2)+DELTA(N2)*XLOAD(N1) (C 55)
800 CONTINUE (C 56)
DO 802 N2=1,28 (C 57)
802 DELTA(N2)=XDELTA(N2)*SUML (C 58)
WRITE (6,149) XSTAR (C 59)
WRITE (6,150) (DELTA(I),I=1,25,4) (C 60)
WRITE (6,151) (DELTA(I),I=26,4) (C 61)
WRITE (6,152) (DELTA(I),I=27,4) (C 62)
WRITE (6,153) (DELTA(I),I=28,4) (C 63)
DO 810 N2=1,28 (C 64)
810 XDELTA(N2)=0.0 (C 65)
M1=M1+1 (C 66)

```

# Appendix C - Concluded

```

      IF (M1.LT.12) GO TO 804                                (C 67)
      GO TO 1                                                  (C 68)
103  FORMAT (11,F9.3,6F10.3)                                (C 69)
149  FORMAT (10X12HY/SEMISPAN =F4.1/)                       (C 70)
150  FORMAT (3X5H(W,L)7(F17.4))                             (C 71)
151  FORMAT (3X5H(U,L)7(F17.4))                             (C 72)
152  FORMAT (3X5H(W,D)7(F17.4))                             (C 73)
153  FORMAT (3X5H(U,D)7(F17.4)///)                          (C 74)
210  FORMAT (1X131(1H-))                                     (C 75)
211  FORMAT (1X1HI11X1HI31X61HCCORRECTION FACTORS FOR CORRECTING FROM A (C 76)
      1WIND TUNNEL WHICH IS25X1HI)                           (C 77)
212  FORMAT (1X1HI11X1HI117(1H-)1HI)                       (C 78)
213  FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (C 79)
      1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)                (C 80)
214  FORMAT (1X1HI3X5FDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (C 81)
      1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (C 82)
      2I)                                                       (C 83)
215  FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 16X4H (C 84)
      1ONLY6X1HI16X1HI6X4HONLY5X1HI)                         (C 85)
216  FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI)              (C 86)
217  FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (C 87)
      1HI)                                                       (C 88)
218  FORMAT (1X131(1H-))                                     (C 89)
900  FORMAT (1HI///38X*INTERFERENCE DISTRIBUTION OVER SWEEP WING OF FIN (C 90)
      1ITE SPAN*///15X*GAMMA =*F7.3,15X*ZETA =*F7.3,15X,A8* LOADING* (C 91)
      215X*ALPHA =*F7.3//15X*SIGMA =*F7.3,15X*ETA =*F7.3,15X*LAMBDA =* (C 92)
      3F8.3,15X*CHI =*F7.3//)                                  (C 93)
901  FORMAT (////40X*SIGMA EQUALS ZERO - USE AVERAGE INTERFERENCE PROGR (C 94)
      1AM*///)                                                  (C 95)
999  STOP                                                    (C 96)
      END                                                    (C 97)

```

## APPENDIX D

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### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND A SWEEP WING

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE APEX OF THE SWEEP LIFTING LINE. THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE FIRST CARD, ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM LOADING, L=2 FOR ELLIPTIC LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG
ALPHA	ANGLE OF ATTACK OF WING, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, GIVEN ON THE SECOND CARD, ARE

SIGMAT	RATIO OF TAIL SPAN TO TUNNEL WIDTH
TL	TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT
TL	TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)  
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)

(D 1)  
(D 2)

# Appendix D - Continued

DIMENSION XDELTA(28),XLOAD(10),XLE(10),C(8)	(D 3)
REAL LAMBCA	(D 4)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./	(D 5)
XLE(1)=XLE(10)=0.43579	(D 6)
XLE(2)=XLE(9)=0.71422	(D 7)
XLE(3)=XLE(8)=0.86603	(D 8)
XLE(4)=XLE(7)=0.95394	(D 9)
XLE(5)=XLE(6)=0.99499	(D 10)
DO 803 L1=1,28	(D 11)
803 XDELTA(L1)=0.	(D 12)
RAD=.0174532925159	(D 13)
PI=3.14159265358979	(D 14)
1 READ (5,900) LI,ZETA1,ETA1,GAMMA,SIGMAW,LAMBDA,ALPHA,	(D 15)
1 SIGMAT,TL,TH	(D 16)
IF (EOF,5) 999,47	(D 17)
47 IF (LI.EQ.1) GO TO 804	(D 18)
IALPHA=8*ELLIPTIC	(D 19)
SUML=0.031526	(D 20)
DO 808 M2=1,10	(D 21)
808 XLOAD(M2)=XLE(M2)	(D 22)
GO TO 48	(D 23)
804 SUML=0.025	(D 24)
IALPHA=8*HUNIFORM	(D 25)
DO 809 M2=1,10	(D 26)
809 XLOAD(M2)=1.0	(D 27)
48 WRITE (6,901) SIGMAW,TH,IALPHA,GAMMA,ZETA1,SIGMAT,TL,LAMBDA,ALPHA,	(D 28)
1ETA1	(D 29)
WRITE (6,210)	(D 30)
WRITE (6,211)	(D 31)
WRITE (6,212)	(D 32)
WRITE (6,213)	(D 33)
WRITE (6,214)	(D 34)
WRITE (6,215)	(D 35)
WRITE (6,216)	(D 36)
WRITE (6,217)	(D 37)
WRITE (6,218)	(D 38)
LAMBDA=LAMBDA*RAD	(D 39)
ALPHA=ALPHA*RAD	(D 40)
DO 41 K=1,8	(D 41)
IF (SIGMAW.EQ.0..AND.SIGMAT.EQ.0.) GO TO 850	(D 42)
IF (SIGMAW.EQ.0..AND.SIGMAT.NE.0.) GO TO 855	(D 43)
IF (SIGMAW.NE.0..AND.SIGMAT.EQ.0.) GO TO 860	(D 44)
M7=4	(D 45)
N7=10	(D 46)
CONST1=1.0	(D 47)
IF (ETA1.NE.1.) GO TO 812	(D 48)
M7=2	(D 49)
CONST1=2.0	(D 50)
GO TO 812	(D 51)
850 M7=N7=1	(D 52)
XLOAD(1)=1.0	(D 53)
SUML=0.025	(D 54)
CONST1=40.0	(D 55)
GO TO 812	(D 56)
855 M7=4	(D 57)
N7=1	(D 58)
XLOAD(1)=1.0	(D 59)
SUML=0.025	(D 60)
CONST1=10.0	(D 61)
IF (ETA1.NE.1.) GO TO 812	(D 62)
M7=2	(D 63)

# Appendix D - Continued

```

CONST1=20.0 (D 64)
GO TO 812 (D 65)
860 M7=1 (D 66)
N7=10 (D 67)
CONST1=4.0 (D 68)
IF (ETA1.NE.1.) GO TO 812 (D 69)
N7=5 (D 70)
CONST1=8.0 (D 71)
812 DC 801 M1=1,M7 (D 72)
DO 802 N1=1,N7 (D 73)
XSTAR=(2.*FLOAT(N1)-11.)/10. (D 74)
YSTAR=(11.-2.*FLOAT(N1))/10. (D 75)
ZSTAR=(5.-2.*FLOAT(M1))/4. (D 76)
ETA=ETA1+XSTAR*SIGMAW (D 77)
ZETA=ZETA1/(1.-ABS(YSTAR)*SIGMAW*GAMMA*ZETA1*TAN(LAMBDA)*SIN(ALPHA (D 78)
1)) (D 79)
XOVERH=TL*COS(ALPHA)+TH*SIN(ALPHA)-SIGMAW*GAMMA*TAN(LAMBDA)*COS(AL (D 80)
1PHA)*ABS(YSTAR) (D 81)
YOVERH=ZSTAR*SIGMAW*GAMMA-YSTAR*SIGMAW*GAMMA (D 82)
ZOVERH=TH*COS(ALPHA)-TL*SIN(ALPHA)+SIGMAW*GAMMA*TAN(LAMBDA)*SIN(AL (D 83)
1PHA)*ABS(YSTAR) (D 84)
CALL DLTAS (C(K)) (D 85)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
DO 805 L1=1,28 (D 86)
805 XDELTA(L1)=XDELTA(L1)+(DELTA(L1)*XLOAD(N1)) (D 87)
802 CONTINUE (D 88)
801 CONTINUE (D 89)
DO 807 L3=1,28 (D 90)
807 DELTA(L3)=XDELTA(L3)*SUM1*CONST1 (D 91)
WRITE (6,149) C(K) (D 92)
WRITE (6,150) (DELTA(I),I=1,25,4) (D 93)
WRITE (6,151) (DELTA(I),I=2,26,4) (D 94)
WRITE (6,152) (DELTA(I),I=3,27,4) (D 95)
WRITE (6,153) (DELTA(I),I=4,28,4) (D 96)
DO 814 L4=1,28 (D 97)
814 XDELTA(L4)=0. (D 98)
41 CONTINUE (D 99)
GO TO 1 (D 100)
149 FORMAT (5X5HCHI =F7.3/) (D 101)
150 FORMAT (3X5H(W,L)7(F17.4)) (D 102)
151 FORMAT (3X5H(U,L)7(F17.4)) (D 103)
152 FORMAT (3X5H(W,D)7(F17.4)) (D 104)
153 FORMAT (3X5H(U,D)7(F17.4)/) (D 105)
210 FORMAT (1X131(1H-)) (D 106)
211 FORMAT (1X1HI11X1HI31X61HOCORRECTION FACTORS FOR CORRECTING FROM A (D 107)
1WIND TUNNEL WHICH IS25X1HI) (D 108)
212 FORMAT (1X1HI11X1HI117(1H-))1HI) (D 109)
213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (D 110)
1HI6X4HOPEN5X1HI16X1HI5X6HCLOSED4X1HI) (D 111)
214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (D 112)
1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (D 113)
2I) (D 114)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GRCUND EFFECT) 16X4H (D 115)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (D 116)
216 FORMAT (1X1HI11X1HI84(1H-))1HI32(1H-))1HI) (D 117)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1 (D 118)
1HI) (D 119)
218 FORMAT (1X131(1H-)/) (D 120)
900 FORMAT (11,F9.3,5F10.3/3F10.3) (D 121)
901 FORMAT (1H1///39X*INTERFERENCE AT TAIL BEHIND SWEEP WING OF FINITE (D 122)
1 SPAN*///10X*SIGMA (WING) =*F7.3,7X*TAIL HEIGHT =*F7.3,8XA8,* LOAD (D 123)

```



Appendix D – Concluded

```
2ING*7X*GAMMA =*F8.3,7X*ZETA=*F7.3//10X*SIGMA (TAIL) =*F7.3,7X*TAIL (D 124)
3 LENGTH =*F7.3,8X*LAMBDA =*F8.3,7X*ALPHA =*F8.3,7X*ETA =*F7.3///) (D 125)
999  STOP (D 126)
    END (D 127)
```

## APPENDIX E

### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A SWEEP WING CAUSED BY THE PRESENCE OF LIFTING JETS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT, AND ABOVE, ADDRESS 1. NOTE THAT THE REFERENCE ORIGIN HAS BEEN CHOSEN AT THE APEX OF THE SWEEP LIFTING LINE. ONLY ONE CONFIGURATION OF JETS CAN BE TREATED PER RUN. ANY NUMBER OF WING CONFIGURATIONS, MAY, HOWEVER, BE TREATED IN ONE RUN FOR THIS ONE JET CONFIGURATION. THE FIRST VARIABLE REQUIRED (IN FORMAT 103) IS

NJ            TOTAL NUMBER OF JETS IN CONFIGURATION

AS MANY AS 10 JETS CAN BE CONSIDERED BY THE PROGRAM AS LISTED HEREIN. IF MORE JETS ARE REQUIRED, AS MANY AS 99 CAN BE OBTAINED BY SUITABLE INCREASES IN XH1, YH1, ZH1, AND XLOAD IN THE DIMENSION STATEMENT. FURTHER INCREASES REQUIRE ALTERATION OF FORMAT 103.

THE NEXT VARIABLES REQUIRED ARE THE LOCATIONS AND THE RELATIVE STRENGTHS OF THE JETS. AS MANY CARDS MAY BE USED AS NEEDED, HOWEVER, THE TOTAL NUMBER OF SETS OF DATA MUST AGREE WITH NJ. INPUT VARIABLES FOR THE JETS (IN FORMAT 904) ARE

XH1	X-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
YH1	Y-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
ZH1	Z-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
XLOAD	RELATIVE PORTION OF LOAD CARRIED BY JET

SUBSEQUENT TO SPECIFICATION OF THE JETS, MODEL CONFIGURATIONS ARE GIVEN (ONE CARD PER CASE) IN FORMAT 900. THE REQUIRED INPUT VARIABLES ARE

# Appendix E - Continued

ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR  
 ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH  
 GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL  
 SIGMA RATIO OF WING SPAN TO TUNNEL WIDTH  
 LAMBDA WING SWEEP ANGLE, DEG  
 ALPHA ANGLE OF ATTACK OF WING, DEG

```

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)      (E 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)         (E 2)
DIMENSION XDELTA(28),XLOAD(10),XH1(10),YH1(10),ZH1(10),C(8)  (E 3)
REAL LAMBDA                                                    (E 4)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./         (E 5)
DO 803 L1=1,28                                                 (E 6)
803 XDELTA(L1)=0.                                              (E 7)
RAD=.0174532925199                                           (E 8)
IFIRST=0                                                       (E 9)
READ (5,103) NJ                                               (E 10)
READ (5,904) (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)         (E 11)
1 READ (5,905) ZETA1,ETA1,GAMMA,SIGMA,LAMBDA,ALPHA           (E 12)
IF (EOF,5) 999,48                                             (E 13)
48 IF (IFIRST.NE.0) GO TO 47                                   (E 14)
WRITE (6,903) (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)        (E 15)
47 WRITE (6,901) GAMMA,ZETA1,LAMBDA,SIGMA,ETA1,ALPHA          (E 16)
WRITE (6,210)                                                  (E 17)
WRITE (6,211)                                                  (E 18)
WRITE (6,212)                                                  (E 19)
WRITE (6,213)                                                  (E 20)
WRITE (6,214)                                                  (E 21)
WRITE (6,215)                                                  (E 22)
WRITE (6,216)                                                  (E 23)
WRITE (6,217)                                                  (E 24)
WRITE (6,218)                                                  (E 25)
IFIRST=1                                                       (E 26)
LAMBCA=LAMBDA*RAD                                              (E 27)
ALPHA=ALPHA*RAD                                                (E 28)
SUML=0.                                                         (E 29)
DO 820 M2=1,NJ                                                 (E 30)
SUML=SUML+XLOAD(M2)                                           (E 31)
820 CONTINUE                                                  (E 32)
SUML=1./((10.*SUML)                                           (E 33)
DO 41 K=1,8                                                     (E 34)
IF (ETA1.NE.1.) GO TO 813                                     (E 35)
M3=0                                                            (E 36)
DO 815 M4=1,NJ                                                 (E 37)
IF (YH1(M4).EQ.0.) GO TO 817                                   (E 38)
DO 816 M5=1,NJ                                                 (E 39)
IF (M4.EQ.M5) GO TO 816                                        (E 40)
IF (XH1(M4).EQ.XH1(M5).AND.ZH1(M4).EQ.ZH1(M5).AND.YH1(M4).EQ.-YH1( (E 41)
1M5)) GO TO 821                                               (E 42)
GO TO 816                                                       (E 43)
821 M3=M3+1                                                    (E 44)
816 CONTINUE                                                  (E 45)

```

# Appendix E - Continued

```

      GO TO 815 (E 46)
817 M3=M3+1 (E 47)
815 CONTINUE (E 48)
      IF (M3.NE.NJ) GO TO 813 (E 49)
      IALPHA=10H SYMMETRIC (E 50)
      M6=N6=1 (E 51)
      M7=5 (E 52)
      N7=NJ (E 53)
      CONST1=2. (E 54)
      IF (SIGMA.NE.0.) GO TO 812 (E 55)
      M7=1 (E 56)
      CONST1=10. (E 57)
      GO TO 812 (E 58)
813 M6=N6=1 (E 59)
      M7=10 (E 60)
      N7=NJ (E 61)
      CONST1=1. (E 62)
      IALPHA=10HASYMMETRIC (E 63)
      IF (SIGMA.NE.0.) GO TO 812 (E 64)
      M7=1 (E 65)
      CONST1=10. (E 66)
812 DO 801 M1=M6,M7 (E 67)
      DO 802 N1=N6,N7 (E 68)
      YSTAR=(11.-2.*FLOAT(M1))/17. (E 69)
      ZETA=ZETA1/ (1.+ZETA1*(ZH1(N1)*COS( ALPHA)-XH1(N1)*SIN( ALPHA))) (E 70)
      ETA=ETA1-((1./GAMMA)*YH1(N1)) (E 71)
      XOVERH=ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*COS( ALPHA)-(XH1(N1)*COS( (E 72)
1 ALPHA))- (ZH1(N1)*SIN( ALPHA)) (E 73)
      YOVERH=YSTAR*SIGMA*GAMMA-YH1(N1) (E 74)
      ZOVERH=-ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*SIN( ALPHA)-(ZH1(N1)*COS (E 75)
1( ALPHA))+(XH1(N1)*SIN( ALPHA)) (E 76)
      CALL DLTAS (C(K)) (E 77)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
      DO 805 L1=1,28 (E 78)
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1) (E 79)
802 CONTINUE (E 80)
801 CONTINUE (E 81)
      DO 807 L3=1,28 (E 82)
807 DELTA(L3)=XDELTA(L3)*SUML*CONST1 (E 83)
      WRITE (6,149) C(K),IALPHA (E 84)
      WRITE (6,150) (DELTA(I),I=1,25,4) (E 85)
      WRITE (6,151) (DELTA(I),I=2,26,4) (E 86)
      WRITE (6,152) (DELTA(I),I=3,27,4) (E 87)
      WRITE (6,153) (DELTA(I),I=4,28,4) (E 88)
      DO 814 L4=1,28 (E 89)
814 XDELTA(L4)=0. (E 90)
      41 CONTINUE (E 91)
      GO TO 1 (E 92)
103 FORMAT (I2) (E 93)
149 FORMAT (1X*CHI =*F7.3,6X*10,* JET CONFIGURATION*) (E 94)
150 FORMAT (3X5H(W,L)7(F17.4)) (E 95)
151 FORMAT (3X5H(U,L)7(F17.4)) (E 96)
152 FORMAT (3X5H(W,D)7(F17.4)) (E 97)
153 FORMAT (3X5H(U,D)7(F17.4)//) (E 98)
210 FORMAT (1X13I(1H-)) (E 99)
211 FORMAT (1X1H11X1H131X61HCORRECTION FACTORS FOR CORRECTING FROM A (E 100)
1 WIND TUNNEL WHICH IS25X1H1) (E 101)
212 FORMAT (1X1H11X1H1117(1H-)1H1) (E 102)
213 FORMAT (1X1H11X1H116X1H15X6HCLOSED5X1H116X1H12X12HCLOSED FLOOR2X1 (E 103)
1H16X4HOPEN6X1H116X1H15X6HCLOSED4X1H1) (E 104)
214 FORMAT (1X1H13X5HDELTA3X1H15X6HCLOSED5X1H1+X9HON BOTTOM3X1H16X4HOP (E 105)

```

# Appendix E - Concluded

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1EN6X1HI6X4HONLY6X1HI5X5HFLJDR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (E 106)
2I) (E 107)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 16X4H (E 108)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (E 109)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (E 110)
217 FORMAT (1X1HI11X1HI36X11H-TO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (E 111)
1HI) (E 112)
218 FORMAT (1X131(1H-)/) (E 113)
900 FORMAT (6F10.3) (E 114)
901 FORMAT (1H1///37X*AVERAGE INTERFERENCE OF SEVERAL JETS ON A FINITE (E 115)
1 SWEPT WING*///30X*GAMMA =*F7.3,16X*ZETA =*F7.3,15X*LAMBDA =* (E 116)
2F7.3//30X*SIGMA =*F7.3,16X*ETA =*F7.3,15X*ALPHA =*F7.3//) (E 117)
903 FORMAT (//101X*RELATIVE*/25X*XOVERH*20X*YOVERH*20X*ZOVERH*18X (E 118)
1*STRENGTH*//124XF7.3,19XF7.3,19XF7.3,19XF6.3//) (E 119)
904 FORMAT (3F7.3,F5.3,3F7.3,F5.3,3F7.3,F5.3) (E 120)
999 STOP (E 121)
END (E 122)

```

## APPENDIX F

-----

### FORTTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF WIND-TUNNEL INTERFERENCE OVER THE SPAN OF A SWEEP WING CAUSED BY THE PRESENCE OF LIFTING JETS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT, AND ABOVE, ADDRESS 1. NOTE THAT THE REFERENCE ORIGIN HAS BEEN CHOSEN AT THE APEX OF THE SWEEP LIFTING LINE. ONLY ONE CONFIGURATION OF JETS CAN BE TREATED PER RUN. ANY NUMBER OF WING CONFIGURATIONS, MAY, HOWEVER, BE TREATED IN ONE RUN FOR THIS ONE JET CONFIGURATION. THE FIRST VARIABLE REQUIRED (IN FORMAT 103) IS

NJ            TOTAL NUMBER OF JETS IN CONFIGURATION

AS MANY AS 10 JETS CAN BE CONSIDERED BY THE PROGRAM AS LISTED HEREIN. IF MORE JETS ARE REQUIRED, AS MANY AS 99 CAN BE OBTAINED BY SUITABLE INCREASES IN XH1, YH1, ZH1, AND XLOAD IN THE DIMENSION STATEMENT. FURTHER INCREASES REQUIRE ALTERATION OF FORMAT 103.

THE NEXT VARIABLES REQUIRED ARE THE LOCATIONS AND THE RELATIVE STRENGTHS OF THE JETS. AS MANY CARDS MAY BE USED AS NEEDED, HOWEVER, THE TOTAL NUMBER OF SETS OF DATA MUST AGREE WITH NJ. INPUT VARIABLES FOR THE JETS (IN FORMAT 904) ARE

XH1	X-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
YH1	Y-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
ZH1	Z-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
XLOAD	RELATIVE PORTION OF LOAD CARRIED BY JET

## Appendix F – Continued

SUBSEQUENT TO SPECIFICATION OF THE JETS, MODEL CONFIGURATIONS ARE GIVEN (ONE CARD PER CASE) IN FORMAT 900. THE REQUIRED INPUT VARIABLES ARE

ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG
ALPHA	ANGLE OF ATTACK OF WING, DEG
C	EFFECTIVE WAKE SKEW-ANGLE, DEG

IN SYMMETRICAL CASES THIS PROGRAM COMPUTES THE INTERFERENCE DISTRIBUTION OVER ONE SEMISPAN ONLY. THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PROVIDED BY THE PROGRAM OF APPENDIX E.

	PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)	(F 1)
	COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)	(F 2)
	DIMENSION XDELTA(28),XLOAD(10),XH1(10),YH1(10),ZH1(10),DATE(2)	(F 3)
	REAL LAMBDA	(F 4)
	DO 803 L1=1,28	(F 5)
803	XDELTA(L1)=0.	(F 6)
	RAD=.0174532925199	(F 7)
	IFIRST=0	(F 8)
	READ (5,103) NJ	(F 9)
	READ (5,904) (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)	(F 10)
1	READ (5,900) ZETA1,ETA1,GAMMA,SIGMA,LAMBDA,ALPHA,C	(F 11)
	IF (EOF,5) 999,48	(F 12)
48	IF (IFIRST.NE.0) GO TO 47	(F 13)
	WRITE (6,903) (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)	(F 14)
47	WRITE (6,901) GAMMA,ZETA1,LAMBDA,SIGMA,ETA1,ALPHA,C	(F 15)
	WRITE (6,210)	(F 16)
	WRITE (6,211)	(F 17)
	WRITE (6,212)	(F 18)
	WRITE (6,213)	(F 19)
	WRITE (6,214)	(F 20)
	WRITE (6,215)	(F 21)
	WRITE (6,216)	(F 22)
	WRITE (6,217)	(F 23)
	WRITE (6,218)	(F 24)
	IFIRST=1	(F 25)
	LAMBDA=LAMBDA*RAD	(F 26)
	ALPHA=ALPHA*RAD	(F 27)
	SUML=0.	(F 28)
	DO 820 M2=1,NJ	(F 29)
	SUML=SUML+XLOAD(M2)	(F 30)
820	CONTINUE	(F 31)
	SUML=1./SUML	(F 32)
	IF (SIGMA.NE.C.) GO TO 811	(F 33)
	WRITE (6,905)	(F 34)
	CALL DAYTIM (DATE)	(F 35)

# Appendix F - Continued

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WRITE (6,906) DATE (F 36)
GO TO 1 (F 37)
811 IF (ETA1.NE.1.) GO TO 813 (F 38)
M3=0 (F 39)
DO 815 M4=1,NJ (F 40)
IF (YH1(M4).EQ.0.) GO TO 817 (F 41)
DO 816 M5=1,NJ (F 42)
IF (M4.EQ.M5) GO TO 816 (F 43)
IF (XH1(M4).EQ.XH1(M5).AND.ZH1(M4).EQ.ZH1(M5).AND.YH1(M4).EQ.-YH1( (F 44)
1M5)) GO TO 821 (F 45)
GO TO 816 (F 46)
821 M3=M3+1 (F 47)
816 CONTINUE (F 48)
GO TO 815 (F 49)
817 M3=M3+1 (F 50)
815 CONTINUE (F 51)
IF (M3.NE.NJ) GO TO 813 (F 52)
IALPHA=10H SYMMETRIC (F 53)
MICHEK=5 (F 54)
GO TO 812 (F 55)
813 MICHEK=11 (F 56)
IALPHA=10HASYMMETRIC (F 57)
812 M1=0 (F 58)
801 DO 802 N1=1,NJ (F 59)
YSTAR=(11.-2.*FLOAT(M1))/10. (F 60)
ZETA=ZETA1/ (1.+ZETA1*(ZH1(N1)*COS(ALPHA)-XH1(N1)*SIN(ALPHA))) (F 61)
ETA=ETA1-((1./GAMMA)*YH1(N1)) (F 62)
XOVERH=ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*COS(ALPHA)-(XH1(N1)*COS( (F 63)
1ALPHA))-(ZH1(N1)*SIN(ALPHA)) (F 64)
YOVERH=YSTAR*SIGMA*GAMMA-YH1(N1) (F 65)
ZOVERH=-ABS(YSTAR)*SIGMA*GAMMA*TAN(LAMBDA)*SIN(ALPHA)-(ZH1(N1)*COS (F 66)
1(ALPHA))+(XH1(N1)*SIN(ALPHA)) (F 67)
CALL DLTAS (C) (F 68)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
DO 805 L1=1,28 (F 69)
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1) (F 70)
802 CONTINUE (F 71)
DO 807 L3=1,28 (F 72)
807 DELTA(L3)=XDELTA(L3)*SUML (F 73)
WRITE (6,149) YSTAR,IALPHA (F 74)
WRITE (6,150) (DELTA(I),I=1,25,4) (F 75)
WRITE (6,151) (DELTA(I),I=2,26,4) (F 76)
WRITE (6,152) (DELTA(I),I=3,27,4) (F 77)
WRITE (6,153) (DELTA(I),I=4,28,4) (F 78)
DO 814 L4=1,28 (F 79)
814 XDELTA(L4)=0. (F 80)
M1=M1+1 (F 81)
IF (M1.LE.MICHEK) GO TO 801 (F 82)
GO TO 1 (F 83)
103 FORMAT (I2) (F 84)
149 FORMAT (//1X*Y/SEMISPAN =*F4.1,10X*10* JET CONFIGURATION*/) (F 85)
150 FORMAT (3X5H(W,L)7(F17.4)) (F 86)
151 FORMAT (3X5H(U,L)7(F17.4)) (F 87)
152 FORMAT (3X5H(W,D)7(F17.4)) (F 88)
153 FORMAT (3X5H(U,D)7(F17.4)) (F 89)
210 FORMAT (1X131(1H-)) (F 90)
211 FORMAT (1X1H111X1H131X61HCORRECTION FACTORS FOR CORRECTING FROM A (F 91)
1WIND TUNNEL WHICH IS25X1HI) (F 92)
212 FORMAT (1X1H111X1H1117(1H-)1HI) (F 93)
213 FORMAT (1X1H111X1H116X1H15X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (F 94)
1HI16X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI) (F 95)

```



# Appendix F – Concluded

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214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (F 96)
1EN6X1HI6X4HONLY6X1HI5X5HFLDOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (F 97)
2I) (F 98)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 16X4H (F 99)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (F 100)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (F 101)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (F 102)
1HI) (F 103)
218 FORMAT (1X131(1H-)) (F 104)
900 FORMAT (7F10.3) (F 105)
901 FORMAT (1H1///37X*DISTRIBUTION OVER FINITE SWEEP WING CAUSED BY SE (F 106)
1VERAL JETS*//30X*GAMMA =*F7.3,16X*ZETA =*F7.3,15X*LAMBDA =*F7.3// (F 107)
230X*SIGMA =*F7.3,16X*ETA =*F7.3,15X*ALPHA =*F7.3//60X*CHI =* (F 108)
3F7.3//) (F 109)
903 FORMAT (101X*RELATIVE*/25X*XOVERH*20X*YOVERH*20X*ZOVERH*18X (F 110)
1*STRENGTH*//124XF7.3,19XF7.3,19XF7.3,19XF6.3//)) (F 111)
904 FORMAT (3F7.3,F5.3,3F7.3,F5.3,3F7.3,F5.3) (F 112)
905 FORMAT (////40X*SIGMA EQUALS ZERO - USE AVERAGE INTERFERENCE PROGR (F 113)
1AM*//) (F 114)
999 STOP (F 115)
END (F 116)

```

## APPENDIX G

### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL CAUSED BY THE PRESENCE OF LIFTING JETS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT, AND ABOVE, ADDRESS 1. NOTE THAT THE REFERENCE ORIGIN HAS BEEN CHOSEN AT THE APEX OF THE SWEEP LIFTING LINE. ONLY ONE CONFIGURATION OF JETS CAN BE TREATED PER RUN. ANY NUMBER OF WING CONFIGURATIONS, MAY, HOWEVER, BE TREATED IN ONE RUN FOR THIS ONE JET CONFIGURATION. THE FIRST VARIABLE REQUIRED (IN FORMAT 103) IS

NJ            TOTAL NUMBER OF JETS IN CONFIGURATION

AS MANY AS 10 JETS CAN BE CONSIDERED BY THE PROGRAM AS LISTED HEREIN. IF MORE JETS ARE REQUIRED, AS MANY AS 99 CAN BE OBTAINED BY SUITABLE INCREASES IN XH1, YH1, ZH1, AND XLOAD IN THE DIMENSION STATEMENT. FURTHER INCREASES REQUIRE ALTERATION OF FORMAT 103.

THE NEXT VARIABLES REQUIRED ARE THE LOCATIONS AND THE RELATIVE STRENGTHS OF THE JETS. AS MANY CARDS MAY BE USED AS NEEDED, HOWEVER, THE TOTAL NUMBER OF SETS OF DATA MUST AGREE WITH NJ. INPUT VARIABLES FOR THE JETS (IN FORMAT 904) ARE

XH1	X-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
YH1	Y-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
ZH1	Z-COORDINATE OF NOZZLE EXIT AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO THE TUNNEL SEMIHEIGHT
XLOAD	RELATIVE PORTION OF LOAD CARRIED BY JET

SUBSEQUENT TO SPECIFICATION OF THE JETS, MODEL CONFIGURATIONS ARE GIVEN (ONE CARD PER CASE) IN FORMAT 903. THE REQUIRED INPUT VARIABLES ARE

# Appendix G - Continued

ZETA1 SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR  
 ETA1 DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH  
 GAMMA WIDTH-HEIGHT RATIO OF WIND TUNNEL  
 SIGMAT RATIO OF TAIL SPAN TO TUNNEL WIDTH  
 TL TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT  
 TH TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO TUNNEL SEMIHEIGHT  
 ALPHA ANGLE OF ATTACK OF WING, DEG

```

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)          (G 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)             (G 2)
DIMENSION XDELTA(28),XLOAD(10),XH1(10),YH1(10),ZH1(10),C(8)      (G 3)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./             (G 4)
DO 803 L1=1,28                                                     (G 5)
803 XDELTA(L1)=0.                                                  (G 6)
PI=3.14159265358979                                              (G 7)
RAD=.0174532925199                                              (G 8)
IFIRST=0                                                         (G 9)
READ (5,103) NJ                                                  (G 10)
READ (5,904) (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)            (G 11)
1 READ (5,900) ZETA1,ETA1,GAMMA,SIGMAT,TL,TH,ALPHA              (G 12)
IF (EOF,5) 999,48                                                (G 13)
48 IF (IFIRST.NE.0) GO TO 47                                       (G 14)
WRITE (6,903) (XH1(I),YH1(I),ZH1(I),XLOAD(I),I=1,NJ)           (G 15)
47 WRITE (6,901) GAMMA,ZETA1,TL,SIGMAT,ETA1,TH,ALPHA            (G 16)
WRITE (6,210)                                                     (G 17)
WRITE (6,211)                                                     (G 18)
WRITE (6,212)                                                     (G 19)
WRITE (6,213)                                                     (G 20)
WRITE (6,214)                                                     (G 21)
WRITE (6,215)                                                     (G 22)
WRITE (6,216)                                                     (G 23)
WRITE (6,217)                                                     (G 24)
WRITE (6,218)                                                     (G 25)
IFIRST=1                                                         (G 26)
LAMBDA=LAMBDA*RAD                                                (G 27)
ALPHA=ALPHA*RAD                                                  (G 28)
SUML=0.                                                         (G 29)
DC 820 M2=1,NJ                                                    (G 30)
SUML=SUML+XLOAD(M2)                                              (G 31)
820 CONTINUE                                                     (G 32)
SUML=1./(4.*SUML)                                                (G 33)
DO 41 K=1,8                                                       (G 34)
IF (ETA1.NE.1.) GO TO 813                                         (G 35)
M3=0                                                             (G 36)
DO 815 M4=1,NJ                                                    (G 37)
IF (YH1(M4).EQ.0.) GO TO 817                                       (G 38)
DO 816 M5=1,NJ                                                    (G 39)
IF (M4.EQ.M5) GO TO 816                                           (G 40)
IF (XH1(M4).EQ.XH1(M5).AND.ZH1(M4).EQ.ZH1(M5).AND.YH1(M4).EQ.-YH1( (G 41)

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# Appendix G - Continued

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1M5)) GO TO 821 (G 42)
GO TO 816 (G 43)
821 M3=M3+1 (G 44)
816 CONTINUE (G 45)
GO TO 815 (G 46)
817 M3=M3+1 (G 47)
815 CONTINUE (G 48)
IF (M3.NE.NJ) GO TO 813 (G 49)
IALPHA=10H SYMMETRIC (G 50)
M6=N6=1 (G 51)
M7=2 (G 52)
N7=NJ (G 53)
CONST1=2. (G 54)
IF (SIGMAT.NE.0.) GO TO 812 (G 55)
M7=1 (G 56)
CONST1=4. (G 57)
GO TO 812 (G 58)
813 M6=N6=1 (G 59)
M7=4 (G 60)
N7=NJ (G 61)
CONST1=1. (G 62)
IALPHA=10HASYMMETRIC (G 63)
IF (SIGMAT.NE.0.) GO TO 812 (G 64)
M7=1 (G 65)
CONST1=4. (G 66)
812 DO 801 M1=M6,M7 (G 67)
DO 802 N1=N6,N7 (G 68)
YSTAR=(5.-2.*FLOAT(M1))/4. (G 69)
ZETA=ZETA1/(1.+ZETA1*(ZH1(N1)*COS(ALPHA)-XH1(N1)*SIN(ALPHA))) (G 70)
ETA=ETA1-((1./GAMMA)*YH1(N1)) (G 71)
XOVERH=(TL-XH1(N1))*COS(ALPHA)+(TH-ZH1(N1))*SIN(ALPHA) (G 72)
YOVERH=YSTAR*SIGMAT*GAMMA-YH1(N1) (G 73)
ZOVERH=(TH-ZH1(N1))*COS(ALPHA)-(TL-XH1(N1))*SIN(ALPHA) (G 74)
CALL DLTAS (C(K)) (G 75)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
DO 805 L1=1,28 (G 76)
805 XDELTA(L1)=XDELTA(L1)+(DELTA(L1)*XLOAD(N1)) (G 77)
802 CONTINUE (G 78)
801 CONTINUE (G 79)
DO 807 L3=1,28 (G 80)
807 DELTA(L3)=XDELTA(L3)*SUM1*CONST1 (G 81)
WRITE (6,149) C(K),IALPHA (G 82)
WRITE (6,150) (DELTA(I),I=1,25,4) (G 83)
WRITE (6,151) (DELTA(I),I=2,26,4) (G 84)
WRITE (6,152) (DELTA(I),I=3,27,4) (G 85)
WRITE (6,153) (DELTA(I),I=4,28,4) (G 86)
DO 814 L4=1,28 (G 87)
814 XDELTA(L4)=0. (G 88)
41 CONTINUE (G 89)
GO TO 1 (G 90)
103 FORMAT (I2) (G 91)
149 FORMAT (//1X*CHI =*F7.3,6X10,* JET CONFIGURATION*/) (G 92)
150 FORMAT (3X5H(W,L)7(F17.4)) (G 93)
151 FORMAT (3X5H(U,L)7(F17.4)) (G 94)
152 FORMAT (3X5H(W,D)7(F17.4)) (G 95)
153 FORMAT (3X5H(U,D)7(F17.4)) (G 96)
210 FORMAT (1X131(1H-)) (G 97)
211 FORMAT (1X1HI11X1HI31X61H CORRECTION FACTORS FOR CORRECTING FROM A (G 98)
1WIND TUNNEL WHICH IS25X1HI) (G 99)
212 FORMAT (1X1HI11X1HI117(1H-)1HI) (G 100)
213 FORMAT (1X1HI11X1HI16X1HI5X6H CLOSED5X1HI16X1HI2X12H CLOSED FLOOR2X1 (G 101)

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# Appendix G - Concluded

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1HI6X4HOPEN6X1HI16X1HI5X6HCL3SED4X1HI) (G 102)
214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (G 103)
1EN6X1HI6X4HONLY6X1HI5X5HFL3OR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (G 104)
2I) (G 105)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 16X4H (G 106)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (G 107)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (G 108)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (G 109)
1HI) (G 110)
218 FORMAT (1X131(1H-)) (G 111)
900 FORMAT (7F10.3) (G 112)
901 FORMAT (1H1///37X*AVERAGE INTERFERENCE AT FINITE TAIL CAUSED BY SE (G 113)
1VERAL JETS*//31X*GAMMA =*F7.3,10X*ZETA =*F7.3,10X*TAIL LENGTH/H (G 114)
2 =*F6.3//31X*SIGMA(T) =*F7.3,10X*ETA =*F7.3,10X*TAIL HEIGHT/H =* (G 115)
2F6.3//57X*ALPHA =*F9.3//) (G 116)
903 FORMAT (101X*RELATIVE*/25X*XOVERH*20X*YOVERH*20X*ZOVERH*18X (G 117)
1*STRENGTH*//(24XF7.3,19XF7.3,19XF7.3,19XF6.3//)) (G 118)
904 FORMAT (3F7.3,F5.3,3F7.3,F5.3,3F7.3,F5.3) (G 119)
999 STOP (G 120)
END (G 121)

```

## APPENDIX H

### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES ARE

LI            LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2  
              FOR TRIANGULAR DISK-LOAD DISTRIBUTION  
ZETA1        SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR  
ETA1        DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL  
              SEMIWIDTH  
GAMMA        WIDTH-HEIGHT RATIO OF WIND TUNNEL  
SIGMA        RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH  
ALPHA        ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

```

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)           (H 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)             (H 2)
DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20),C(8)   (H 3)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/              (H 4)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/               (H 5)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./              (H 6)
PI=3.14159265358979                                               (H 7)
RAD=0.0174532925199                                              (H 8)
DO 803 L1=1,28                                                     (H 9)
803 XDELTA(L1)=0.                                                  (H 10)
   PSI(1)=(PI/4.)                                                  (H 11)
   PSI(2)=3.*PSI(1)                                                 (H 12)
   PSI(3)=5.*PSI(1)                                                 (H 13)
   PSI(4)=7.*PSI(1)                                                 (H 14)
   PSI(5)=PSI(13)=(PI/8.)                                           (H 15)
   PSI(6)=PSI(14)=3.*PSI(5)                                         (H 16)
   PSI(7)=PSI(15)=5.*PSI(5)                                         (H 17)
   PSI(8)=PSI(16)=7.*PSI(5)                                         (H 18)
   PSI(9)=PSI(17)=9.*PSI(5)                                         (H 19)

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# Appendix H – Continued

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      PSI(10)=PSI(18)=11.*PSI(5)                      (H 20)
      PSI(11)=PSI(19)=13.*PSI(5)                      (H 21)
      PSI(12)=PSI(20)=15.*PSI(5)                      (H 22)
1    READ (5,900) LI,ZETA1,ETA1,GAMMA,SIGMA,ALPHA      (H 23)
      SUML=.0025                                       (H 24)
      IF (EOF,5) 999,47                               (H 25)
47   IF (LI.EQ.1) GO TO 804                            (H 26)
      IALPHA=10*TRIANGULAR                            (H 27)
      DO 808 M2=1,20                                  (H 28)
808  XLOAD(M2)=RTRIA(M2)                              (H 29)
      GO TO 160                                       (H 30)
804  IALPHA=10*H UNIFORM                              (H 31)
      DO 809 M2=1,20                                  (H 32)
809  XLOAD(M2)=RUNIF(M2)                              (H 33)
160  WRITE (6,901) SIGMA,IALPHA,ZETA1,ETA1,GAMMA,ALPHA (H 34)
      WRITE (6,210)                                    (H 35)
      WRITE (6,211)                                    (H 36)
      WRITE (6,212)                                    (H 37)
      WRITE (6,213)                                    (H 38)
      WRITE (6,214)                                    (H 39)
      WRITE (6,215)                                    (H 40)
      WRITE (6,216)                                    (H 41)
      WRITE (6,217)                                    (H 42)
      WRITE (6,218)                                    (H 43)
      ALPHA=ALPHA*RAD                                  (H 44)
      DO 41 K=1,8                                       (H 45)
      M7=N7=20                                         (H 46)
      IF (SIGMA.NE.0.) GO TO 815                      (H 47)
      M7=N7=1                                          (H 48)
      CONST1=400.                                     (H 49)
      GO TO 812                                       (H 50)
815  IF (ETA1.NE.1.)GO TO 813                         (H 51)
      CONST1=2.                                       (H 52)
      GO TO 812                                       (H 53)
813  CONST1=1.                                       (H 54)
812  DO 801 M1=1,M7                                   (H 55)
      DO 802 N1=1,N7                                   (H 56)
      IF (ETA1.NE.1.) GO TO 811                      (H 57)
      IF (PSI(N1).GT.PI) GO TO 802                   (H 58)
811  ETA=ETA1-(XLOAD(N1)*SIGMA *SIN(PSI(N1)))        (H 59)
      ZETA=1./((1./ZETA1)-(XLOAD(N1)*SIGMA *SIN(ALPHA)*COS(PSI(N1))*GAMM (H 60)
1A))                                                    (H 61)
      XOVERH=SIGMA *GAMMA*COS(ALPHA)*(XLOAD(M1)*COS(PSI(M1))-XLOAD(N1)*C (H 62)
1OS(PSI(N1)))                                           (H 63)
      YOVERH=SIGMA *GAMMA*(XLOAD(M1)*SIN(PSI(M1))-XLOAD(N1)*SIN(PSI(N1)) (H 64)
1)                                                       (H 65)
      ZOVERH=-SIGMA *GAMMA*SIN(ALPHA)*(XLOAD(M1)*COS(PSI(M1))-XLOAD(N1)* (H 66)
1COS(PSI(N1)))                                           (H 67)
      CALL DLTAS (C(K))                                (H 68)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
      DO 805 L1=1,28                                  (H 69)
805  XDELTA(L1)=XDELTA(L1)+DELTA(L1)                  (H 70)
802  CONTINUE                                         (H 71)
801  CONTINUE                                         (H 72)
      DO 807 L3=1,28                                  (H 73)
807  DELTA(L3)=XDELTA(L3)*SUML*CONST1                 (H 74)
      WRITE (6,149) C(K)                              (H 75)
      WRITE (6,150) (DELTA(I),I=1,25,4)              (H 76)
      WRITE (6,151) (DELTA(I),I=2,26,4)              (H 77)
      WRITE (6,152) (DELTA(I),I=3,27,4)              (H 78)
      WRITE (6,153) (DELTA(I),I=4,28,4)              (H 79)

```

# Appendix H - Concluded

```

      CO 814 L4=1,28                                (H 80)
814 XDELTA(L4)=0.                                    (H 81)
      41 CONTINUE                                    (H 82)
      GO TO 1                                         (H 83)
149 FORMAT (//1X*CHI =* F7.3/)                      (H 84)
150 FORMAT (3X5H(W,L)7(F17.4))                     (H 85)
151 FORMAT (3X5H(U,L)7(F17.4))                     (H 86)
152 FORMAT (3X5H(W,D)7(F17.4))                     (H 87)
153 FORMAT (3X5H(U,D)7(F17.4))                     (H 88)
210 FORMAT (1X131(1H-))                             (H 89)
211 FORMAT (1X1HI11X1HI31X61HCCORRECTION FACTORS FOR CORRECTING FROM A (H 90)
      1WIND TUNNEL WHICH IS25X1HI)                 (H 91)
212 FORMAT (1X1HI11X1HI117(1H-))1HI)              (H 92)
213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (H 93)
      1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)       (H 94)
214 FORMAT (1X1HI3X5HDELTA43X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (H 95)
      1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (H 96)
      2I)                                             (H 97)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H (H 98)
      1ONLY6X1HI16X1HI6X4HONLY5X1HI)                (H 99)
216 FORMAT (1X1HI11X1HI84(1H-))1HI32(1H-))1HI)    (H 100)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1 (H 101)
      1HI)                                             (H 102)
218 FORMAT (1X131(1H-))                             (H 103)
900 FORMAT (I1,F9.3,6F10.3)                         (H 104)
901 FORMAT (1HI///40X*AVERAGE INTERFERENCE OVER FINITE SPAN ROTOR*// (H 105)
      140X*SIGMA =*F6.3,12XA10,* LOADING*//40X*ZETA =*F6.3,19X*ETA =*F6. (H 106)
      23//40X*GAMMA =*F6.3,18X*ALPHA =*F5.1//)      (H 107)
999  STOP                                           (H 108)
      END                                           (H 109)

```



# APPENDIX I

## FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF WIND-TUNNEL INTERFERENCE OVER THE LATERAL AXIS OF A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES ARE

LI        LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2  
          FOR TRIANGULAR DISK-LOAD DISTRIBUTION

ZETA1     SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR

ETA1      DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL  
          SEMIWIDTH

GAMMA     WIDTH-HEIGHT RATIO OF WIND TUNNEL

SIGMA     RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH

ALPHA     ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

C         EFFECTIVE WAKE SKEW-ANGLE, DEG

IN SYMMETRICAL CASES THIS PROGRAM COMPUTES THE INTERFERENCE DISTRIBUTION OVER ONE SEMISPAN ONLY. THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PROVIDED BY THE PROGRAM OF APPENDIX H.

```
PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)      (I 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)        (I 2)
DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20)   (I 3)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/          (I 4)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/          (I 5)
PI=3.14159265358979                                           (I 6)
RAD=0.0174532925199                                           (I 7)
PSI(1)=(PI/4.)                                                (I 8)
```

# Appendix I - Continued

```

PSI(2)=3.*PSI(1) (I 9)
PSI(3)=5.*PSI(1) (I 10)
PSI(4)=7.*PSI(1) (I 11)
PSI(5)=PSI(13)=(PI/8.) (I 12)
PSI(6)=PSI(14)=3.*PSI(5) (I 13)
PSI(7)=PSI(15)=5.*PSI(5) (I 14)
PSI(8)=PSI(16)=7.*PSI(5) (I 15)
PSI(9)=PSI(17)=9.*PSI(5) (I 16)
PSI(10)=PSI(18)=11.*PSI(5) (I 17)
PSI(11)=PSI(19)=13.*PSI(5) (I 18)
PSI(12)=PSI(20)=15.*PSI(5) (I 19)
SUML=.05 (I 20)
DO 805 N2=1,28 (I 21)
805 XDELTA(N2)=0. (I 22)
1 READ (5,103) LI,ZETA1,ETA1,GAMMA,SIGMA,ALPHA,C (I 23)
IF (EOF,5) 999,700 (I 24)
700 IF (LI.EQ.1) GO TO 806 (I 25)
IALPHA=10HTRIANGULAR (I 26)
DO 808 M2=1,20 (I 27)
808 XLOAD(M2)=RTRIA(M2) (I 28)
GO TO 702 (I 29)
806 IALPHA=10H UNIFORM (I 30)
DO 809 M2=1,20 (I 31)
809 XLOAD(M2)=RUNIF(M2) (I 32)
702 IF (ETA1.NE.1.) GO TO 813 (I 33)
MICHEK=6 (I 34)
GO TO 47 (I 35)
813 MICHEK=12 (I 36)
47 WRITE (6,900) SIGMA,IALPHA,ZETA1,ETA1,GAMMA,ALPHA,C (I 37)
WRITE (6,210) (I 38)
WRITE (6,211) (I 39)
WRITE (6,212) (I 40)
WRITE (6,213) (I 41)
WRITE (6,214) (I 42)
WRITE (6,215) (I 43)
WRITE (6,216) (I 44)
WRITE (6,217) (I 45)
WRITE (6,218) (I 46)
IF (SIGMA.NE.0.) GO TO 803 (I 47)
WRITE (6,903) (I 48)
GO TO 1 (I 49)
803 ALPHA=ALPHA*RAD (I 50)
M1=0 (I 51)
804 YSTAR=1.2-0.2*FLOAT(M1) (I 52)
DO 800 N1=1,20 (I 53)
ETA=ETA1-(XLOAD(N1)*SIGMA*SIN(PSI(N1))) (I 54)
ZETA=1./((1./ZETA1)-(XLOAD(N1)*SIGMA*SIN(ALPHA)*COS(PSI(N1))*GAMM (I 55)
1A)) (I 56)
XOVERH=-SIGMA*GAMMA*COS(ALPHA)*XLOAD(N1)*COS(PSI(N1)) (I 57)
YOVERH=SIGMA*GAMMA*(YSTAR-(XLOAD(N1)*SIN(PSI(N1)))) (I 58)
ZOVERH=SIGMA*GAMMA*SIN(ALPHA)*XLOAD(N1)*COS(PSI(N1)) (I 59)
CALL DLTAS (C) (I 60)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
DO 801 N2=1,28 (I 61)
801 XDELTA(N2)=XDELTA(N2)+DELTA(N2) (I 62)
800 CONTINUE (I 63)
DO 802 N2=1,28 (I 64)
802 DELTA(N2)=XDELTA(N2)*SUML (I 65)
WRITE (6,149) YSTAR (I 66)
WRITE (6,150) (DELTA(I),I=1,25,4) (I 67)
WRITE (6,151) (DELTA(I),I=2,26,4) (I 68)

```

# Appendix I - Concluded

```

WRITE (6,152) (DELTA(I),I=3,27,4) (I 69)
WRITE (6,153) (DELTA(I),I=4,28,4) (I 70)
DO 810 N2=1,28 (I 71)
810 XDELTA(N2)=0.0 (I 72)
M1=M1+1 (I 73)
IF (M1.LE.M1CHEK) GO TO 804 (I 74)
GO TO 1 (I 75)
103 FORMAT(I1,F9.3,5F10.3) (I 76)
149 FORMAT (//10X*Y/R =*F4.1/) (I 77)
150 FORMAT (3X5H(W,L)7(F17.4)) (I 78)
151 FORMAT (3X5H(U,L)7(F17.4)) (I 79)
152 FORMAT (3X5H(W,D)7(F17.4)) (I 80)
153 FORMAT (3X5H(U,D)7(F17.4)) (I 81)
210 FORMAT (1X131(1H-)) (I 82)
211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A (I 83)
1WIND TUNNEL WHICH IS25X1HI) (I 84)
212 FORMAT (1X1HI11X1HI117(1H-)1HI) (I 85)
213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (I 86)
1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI) (I 87)
214 FORMAT (1X1HI3X5HDELTA43X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (I 88)
1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (I 89)
2I) (I 90)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 15X4H (I 91)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (I 92)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (I 93)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1 (I 94)
1HI) (I 95)
218 FORMAT (1X131(1H-)) (I 96)
900 FORMAT (1H1///31X*INTERFERENCE DISTRIBUTION OVER LATERAL AXIS OF (I 97)
1FINITE SPAN ROTOR*// (I 98)
240X*SIGMA =*F6.3,15XA10,* LOADING*//40X*ZETA =*F6.3,21X*ETA =*F7. (I 99)
33//40X*GAMMA =*F6.3,19X*ALPHA =*F7.3//56X*CHI =*F8.3//) (I 100)
903 FORMAT ( ///40X54HSIGMA EQUALS ZERO --- USE AVERAGE INTERFERENCE P (I 101)
1RCGRAM) (I 102)
999 STOP (I 103)
END (I 104)

```

FORTRAN PROGRAM FOR CALCULATING THE DISTRIBUTION OF  
WIND-TUNNEL INTERFERENCE OVER THE  
LONGITUDINAL AXIS OF A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 5000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES ARE

LI        LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2  
          FOR TRIANGULAR DISK-LOAD DISTRIBUTION

ZETA1    SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR

ETA1     DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL  
          SEMIWIDTH

GAMMA    WIDTH-HEIGHT RATIO OF WIND TUNNEL

SIGMA    RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH

ALPHA    ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

C        EFFECTIVE WAKE SKEW-ANGLE, DEG

INPUT WILL BE FOUND AT ADDRESS 1 (ONE CARD PER CASE) IN FORMAT 103. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES ARE

LI        LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2  
          FOR TRIANGULAR DISK-LOAD DISTRIBUTION

ZETA1    SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR

ETA1     DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL  
          SEMIWIDTH

GAMMA    WIDTH-HEIGHT RATIO OF WIND TUNNEL

# Appendix J - Continued

SIGMA      RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH  
 ALPHA      ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG  
 C          EFFECTIVE WAKE SKEW-ANGLE, DEG

THIS PROGRAM REJECTS CASES OF ZERO SPAN. FOR SUCH CASES, THE INTERFERENCE IS UNIFORM AND THE VALUES ARE IDENTICAL TO THOSE PROVIDED BY THE PROGRAM OF APPENDIX H.

```

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)          (J 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)            (J 2)
DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20)      (J 3)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/            (J 4)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/              (J 5)
PI=3.14159265358979                                             (J 6)
RAD=0.0174532925199                                             (J 7)
PSI(1)=(PI/4.)                                                  (J 8)
PSI(2)=3.*PSI(1)                                                (J 9)
PSI(3)=5.*PSI(1)                                                (J 10)
PSI(4)=7.*PSI(1)                                                (J 11)
PSI(5)=PSI(13)=(PI/8.)                                          (J 12)
PSI(6)=PSI(14)=3.*PSI(5)                                        (J 13)
PSI(7)=PSI(15)=5.*PSI(5)                                        (J 14)
PSI(8)=PSI(16)=7.*PSI(5)                                        (J 15)
PSI(9)=PSI(17)=9.*PSI(5)                                        (J 16)
PSI(10)=PSI(18)=11.*PSI(5)                                     (J 17)
PSI(11)=PSI(19)=13.*PSI(5)                                     (J 18)
PSI(12)=PSI(20)=15.*PSI(5)                                     (J 19)
DO 805 N2=1,28                                                  (J 20)
805 XDELTA(N2)=0.                                                (J 21)
  1 READ (5,103) LI,ZETA1,ETA1,GAMMA,SIGMA,ALPHA,C             (J 22)
  IF (EOF,5) 999,700                                             (J 23)
700 SUML=.05                                                     (J 24)
  CONST=1.                                                       (J 25)
  IF (LI.EC.1) GO TO 806                                         (J 26)
  IALPHA=10HTRIANGULAR                                           (J 27)
  DO 808 M2=1,20                                                 (J 28)
808 XLOAD(M2)=RTRIA(M2)                                          (J 29)
  GO TO 47                                                         (J 30)
806 IALPHA=10H UNIFORM                                           (J 31)
  DO 809 M2=1,20                                                 (J 32)
809 XLOAD(M2)=RUNIF(M2)                                          (J 33)
  47 WRITE (6,900) SIGMA,IALPHA,ZETA1,ETA1,GAMMA,ALPHA,C       (J 34)
  WRITE (6,210)                                                  (J 35)
  WRITE (6,211)                                                  (J 36)
  WRITE (6,212)                                                  (J 37)
  WRITE (6,213)                                                  (J 38)
  WRITE (6,214)                                                  (J 39)
  WRITE (6,215)                                                  (J 40)
  WRITE (6,216)                                                  (J 41)
  WRITE (6,217)                                                  (J 42)
  WRITE (6,218)                                                  (J 43)
  IF (SIGMA.NE.0.) GO TO 803                                     (J 44)
  WRITE (6,503)                                                  (J 45)
  GO TO 1                                                         (J 46)
803 ALPHA=ALPHA*RAD                                              (J 47)
  M1=0                                                            (J 48)

```

# Appendix J – Concluded

```

804 YSTAR=.2*FLJAT(M1)-1.2 (J 49)
DO 800 N1=1,20 (J 50)
IF (ETA1.NE.1.) GO TO 813 (J 51)
CONST=2. (J 52)
IF (PSI(N1).GT.PI) GO TO 830 (J 53)
813 ETA=ETA1-(XLOAD(N1)*SIGMA *SIN(PSI(N1))) (J 54)
ZETA=1./((1./ZETA1)-(XLOAD(N1)*SIGMA *SIN(ALPHA)*COS(PSI(N1))*GAMM (J 55)
1A)) (J 56)
XOVERH=SIGMA *GAMMA*COS(ALPHA)*(YSTAR-(XLOAD(N1)*COS(PSI(N1)))) (J 57)
YOVERH=-SIGMA *GAMMA*XLOAD(N1)*SIN(PSI(N1)) (J 58)
ZOVERH=-SIGMA *GAMMA*SIN(ALPHA)*(YSTAR-(XLOAD(N1)*COS(PSI(N1)))) (J 59)
CALL DLTAS (C) (J 60)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
DO 801 N2=1,28 (J 61)
801 XDELTA(N2)=XDELTA(N2)+DELTA(N2) (J 62)
800 CONTINUE (J 63)
DO 802 N2=1,28 (J 64)
802 DELTA(N2)=XDELTA(N2)*SUM1*CONST (J 65)
WRITE (6,149) YSTAR (J 66)
WRITE (6,150) (DELTA(I),I=1,25,4) (J 67)
WRITE (6,151) (DELTA(I),I=2,26,4) (J 68)
WRITE (6,152) (DELTA(I),I=3,27,4) (J 69)
WRITE (6,153) (DELTA(I),I=4,28,4) (J 70)
DO 810 N2=1,28 (J 71)
810 XDELTA(N2)=0.0 (J 72)
M1=M1+1 (J 73)
IF (M1.LE.12) GO TO 804 (J 74)
GO TO 1 (J 75)
103 FORMAT(I1,F9.3,5F10.3) (J 76)
149 FORMAT (//10X*X/R =*F4.1/) (J 77)
150 FORMAT (3X5H(W,L)7(F17.4)) (J 78)
151 FORMAT (3X5H(U,L)7(F17.4)) (J 79)
152 FORMAT (3X5H(W,D)7(F17.4)) (J 80)
153 FORMAT (3X5H(U,D)7(F17.4)) (J 81)
210 FORMAT (1X131(1H-)) (J 82)
211 FORMAT (1X1HI11X1HI31X61HCORRECTION FACTORS FOR CORRECTING FROM A (J 83)
1WIND TUNNEL WHICH IS25X1HI) (J 84)
212 FORMAT (1X1HI11X1HI117(1H-)1HI) (J 85)
213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (J 86)
1HI6X4HOPEN6X1HI16X1HI5X6HCL3SED4X1HI) (J 87)
214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (J 88)
1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (J 89)
2I) (J 90)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) ISX4H (J 91)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (J 92)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (J 93)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1 (J 94)
1HI) (J 95)
218 FORMAT (1X131(1H-)) (J 96)
900 FORMAT (1H1///28X*INTERFERENCE DISTRIBUTION OVER LONGITUDINAL AXI (J 97)
1S OF FINITE SPAN ROTOR**/ (J 98)
240X*SIGMA =*F6.3,15XA10,* LOADING**/40X*ZETA =*F7.3,23X*ETA =*F5.3 (J 99)
3//40X*GAMMA =*F6.3,19X*ALPHA =*F7.3//56X*CHI =*F8.3//) (J 100)
903 FORMAT ( ///41X5HSIGMA EQUALS ZERO --- USE AVERAGE INTERFERENCE P (J 101)
1RCGRAM) (J 102)
999 STOP (J 103)
END (J 104)

```

## APPENDIX K

-----

### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND A SINGLE ROTOR

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES FOR THE ROTOR, ON THE FIRST CARD, ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHA1	ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, ON THE SECOND CARD, ARE

SIGMAT	RATIO OF TAIL SPAN TO TUNNEL WIDTH
TL	TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
TH	TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
ALPHA2	ANGLE OF ATTACK OF BODY CARRYING TAIL, DEG

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS. THE PROGRAM OF

# Appendix K - Continued

APPENDIX D CAN BE USED FOR SUCH CASES SINCE THE REPRESENTATION OF THE LIFTING SYSTEMS ARE IDENTICAL WHEN THE SPAN IS VANISHINGLY SMALL.

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PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)           (K 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)             (K 2)
DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20),C(8)   (K 3)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./              (K 4)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/              (K 5)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/              (K 6)
RAD=0.0174532925199                                              (K 7)
PI=3.14159265358979                                              (K 8)
PSI(1)=(PI/4.)                                                    (K 9)
PSI(2)=3.*PSI(1)                                                  (K 10)
PSI(3)=5.*PSI(1)                                                  (K 11)
PSI(4)=7.*PSI(1)                                                  (K 12)
PSI(5)=PSI(13)=(PI/8.)                                           (K 13)
PSI(6)=PSI(14)=3.*PSI(5)                                         (K 14)
PSI(7)=PSI(15)=5.*PSI(5)                                         (K 15)
PSI(8)=PSI(16)=7.*PSI(5)                                         (K 16)
PSI(9)=PSI(17)=9.*PSI(5)                                         (K 17)
PSI(10)=PSI(18)=11.*PSI(5)                                       (K 18)
PSI(11)=PSI(19)=13.*PSI(5)                                       (K 19)
PSI(12)=PSI(20)=15.*PSI(5)                                       (K 20)
DO 803 L1=1,28                                                    (K 21)
803 XDELTA(L1)=0.                                                  (K 22)
  1 READ (5,900) LI,ZETA1,ETA1,GAMMA,SIGMAR,ALPHA1,SIGMAT,TL,TH, (K 23)
  1 ALPHA2                                                         (K 24)
    IF (EOF,5) 999,47                                             (K 25)
  47 SUML=0.0125                                                  (K 26)
    IF (LI.EQ.1) GO TO 804                                         (K 27)
    IALPHA=10HTRIANGULAR                                           (K 28)
    DO 808 M2=1,20                                                 (K 29)
  808 XLOAD(M2)=RTRIA(M2)                                          (K 30)
    GO TO 48                                                       (K 31)
  804 IALPHA=10HUNIFORM                                           (K 32)
    DO 809 M2=1,20                                                 (K 33)
  809 XLOAD(M2)=RUNIF(M2)                                          (K 34)
  48 WRITE (6,901) IALPHA,ZETA1,SIGMAR,TL,ALPHA1,ETA1,SIGMAT,TH, (K 35)
  1 ALPHA2,GAMMA                                                  (K 36)
    WRITE (6,210)                                                  (K 37)
    WRITE (6,211)                                                  (K 38)
    WRITE (6,212)                                                  (K 39)
    WRITE (6,213)                                                  (K 40)
    WRITE (6,214)                                                  (K 41)
    WRITE (6,215)                                                  (K 42)
    WRITE (6,216)                                                  (K 43)
    WRITE (6,217)                                                  (K 44)
    WRITE (6,218)                                                  (K 45)
    IF (SIGMAR.NE.0.) GO TO 800                                     (K 46)
    WRITE (6,101)                                                  (K 47)
    GO TO 1                                                         (K 48)
  800 ALPHA1=ALPHA1*RAD                                           (K 49)
    ALPHA2=ALPHA2*RAD                                             (K 50)
    DO 41 K=1,8                                                     (K 51)
    IF (SIGMAT.NE.0.) GO TO 811                                     (K 52)
    N6=M6=M7=1                                                     (K 53)
    N7=20                                                         (K 54)
    CONST1=4.                                                      (K 55)
    GO TO 812                                                       (K 56)
  811 IF (ETA1.NE.1.) GO TO 813                                     (K 57)

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# Appendix K - Continued

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811 IF (ETA1.NE.1.) GO TO 813 (K 58)
      N6=M6=1 (K 59)
      M7=2 (K 60)
      N7=20 (K 61)
      CONST1=2. (K 62)
      GO TO 812 (K 63)
813 M6=N6=1 (K 64)
      M7=4 (K 65)
      N7=20 (K 66)
      CONST1=1 (K 67)
812 DO 801 M1=M6,M7 (K 68)
      DO 802 N1=N6,N7 (K 69)
      ETA=ETA1-(XLJAD(N1)*SIGMAR*SIN(PSI(N1))) (K 70)
      ZETA=1./((1./ZETA1)-(XLOAD(N1)*SIGMAR*GAMMA*SIN(ALPH1)*COS(PSI(N1))) (K 71)
1) (K 72)
      XOVERH=SIGMAR*GAMMA*((TL*CJS(ALPH2))+(TH*SIN(ALPH2))-(XLOAD(N1)*CO (K 73)
      IS(ALPH1)*COS(PSI(N1)))) (K 74)
      XM1=FLOAT(M1) (K 75)
      YOVERH=SIGMAR*GAMMA*(-((2.*XM1-5.)/4.)*(SIGMAT/SIGMAR)-(XLOAD(N1)* (K 76)
      ISIN(PSI(N1)))) (K 77)
      ZOVERH=SIGMAR*GAMMA*((TH*COS(ALPH2))-(TL*SIN(ALPH2))+(XLOAD(N1)*SI (K 78)
      IN(ALPH1)*COS(PSI(N1)))) (K 79)
      CALL DLTAS (C(K)) (K 80)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
      DO 805 L1=1,28 (K 81)
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1) (K 82)
802 CONTINUE (K 83)
801 CONTINUE (K 84)
      DO 807 L3=1,28 (K 85)
807 DELTA(L3)=XDELTA(L3)*SUM1*CONST1 (K 86)
      WRITE (6,149) C(K) (K 87)
      WRITE (6,150) (DELTA(I),I=1,25,4) (K 88)
      WRITE (6,151) (DELTA(I),I=2,26,4) (K 89)
      WRITE (6,152) (DELTA(I),I=3,27,4) (K 90)
      WRITE (6,153) (DELTA(I),I=4,28,4) (K 91)
      DO 814 L4=1,28 (K 92)
814 XDELTA(L4)=0. (K 93)
      41 CONTINUE (K 94)
      GO TO 1 (K 95)
101 FORMAT (//40X*SIGMA(ROTOR) EQUALS ZERO --- USE BASIC PROGRAM*) (K 96)
149 FORMAT (//5X*CHI =#F5.2/) (K 97)
150 FORMAT (3X5H(W,L)7(F17.4)) (K 98)
151 FORMAT (3X5H(U,L)7(F17.4)) (K 99)
152 FORMAT (3X5H(W,D)7(F17.4)) (K 100)
153 FORMAT (3X5H(U,D)7(F17.4)) (K 101)
210 FORMAT (1X131(1H-)) (K 102)
211 FORMAT (1X1HI11X1HI31X61H-CORRECTION FACTORS FOR CORRECTING FROM A (K 103)
      1WIND TUNNEL WHICH IS25X1HI) (K 104)
212 FORMAT (1X1HI11X1HI117(1H-)1HI) (K 105)
213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (K 106)
      1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI) (K 107)
214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (K 108)
      1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (K 109)
      2I) (K 110)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) I6X4H (K 111)
      1ONLY6X1HI16X1HI6X4HONLY5X1HI) (K 112)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (K 113)
217 FORMAT (1X1HI11X1HI36X11H-TO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1 (K 114)
      1HI) (K 115)
218 FORMAT (1X131(1H-)) (K 116)
900 FORMAT (I1,F9.3,4F10.3/4F10.3) (K 117)

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# Appendix K – Concluded

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901 FORMAT (1H1///38X*AVERAGE INTERFERENCE OVER TAIL BEHIND FINITE-SPA (K 118)
900 FORMAT (I1,F9.3,4F10.3/4F10.3) (K 119)
901 FORMAT (1H1///38X*AVERAGE INTERFERENCE OVER TAIL BEHIND FINITE-SPA (K 120)
      1N ROTOR**//56XA10,* LOADING**//15X*ZETA =*F6.3,9X*SIGMA(ROTOR) =* (K 121)
      2F6.3,9X*TAIL LENGTH/R =*F6.3,9X*ALPHA(ROTOR) =*F7.3//15X*ETA =* (K 122)
      3F6.3,9X*SIGMA(TAIL) =*F6.3,9X*TAIL HEIGHT/R =*F6.3,9X*ALPHA(BODY) (K 123)
      4 =*F7.3//58X*GAMMA =*F7.3//) (K 124)
999  STOP (K 125)
      END (K 126)

```

## APPENDIX L

### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER TANDEM ROTORS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE FRONT ROTOR. THE DIAMETERS AND LOAD DISTRIBUTIONS OF THE TWO ROTORS ARE ASSUMED TO BE IDENTICAL. THE REQUIRED INPUT VARIABLES FOR THE FRONT ROTOR, ON THE FIRST CARD, ARE

LI	LOAD INDICATOR, LI=1 FOR UNIFORM DISK-LOAD DISTRIBUTION, LI=2 FOR TRIANGULAR DISK-LOAD DISTRIBUTION
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMA	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
BETA	SIDE-SLIP ANGLE, DEG
ALPHA F	ANGLE OF ATTACK OF TIP-PATH PLANE OF FRONT ROTOR, DEG
ALPHA B	ANGLE OF ATTACK OF BODY CARRYING REAR ROTOR, DEG

THE REQUIRED INPUT VARIABLES FOR THE REAR ROTOR, ON THE SECOND CARD, ARE

LRR	DISTANCE OF REAR ROTOR BEHIND ORIGIN AT ALPHA B = 0, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HRR	HEIGHT OF REAR ROTOR ABOVE ORIGIN AT ALPHA B = 0, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
ALPHA R	ANGLE OF ATTACK OF TIP-PATH PLANE OF REAR ROTOR, DEG

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT EACH ROTOR DUE TO

# Appendix L - Continued

ITS OWN PRESENCE AND THE INTERFERENCE AT EACH ROTOR DUE TO THE PRESENCE OF THE OTHER ROTOR. IN THE LIMIT, WHEN SIGMA IS ZERO, THE TWO ROTORS ARE COINCIDENT, ALL FOUR INTERFERENCES ARE IDENTICAL, AND ONLY ONE SET OF INTERFERENCES IS CALCULATED.

```

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)      (L 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)        (L 2)
DIMENSION XDELTA(28),PSI(20),XLOAD(20),RUNIF(20),RTRIA(20),C(8) (L 3)
REAL LRR                                                       (L 4)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/         (L 5)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/         (L 6)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./         (L 7)
PI=3.14159265358979                                           (L 8)
RAD=0.0174532925199                                           (L 9)
DO 803 L1=1,28                                                 (L 10)
803 XDELTA(L1)=0.                                              (L 11)
   PSI(1)=(PI/4.)                                              (L 12)
   PSI(2)=3.*PSI(1)                                           (L 13)
   PSI(3)=5.*PSI(1)                                           (L 14)
   PSI(4)=7.*PSI(1)                                           (L 15)
   PSI(5)=PSI(13)=(PI/8.)                                      (L 16)
   PSI(6)=PSI(14)=3.*PSI(5)                                    (L 17)
   PSI(7)=PSI(15)=5.*PSI(5)                                    (L 18)
   PSI(8)=PSI(16)=7.*PSI(5)                                    (L 19)
   PSI(9)=PSI(17)=9.*PSI(5)                                    (L 20)
   PSI(10)=PSI(18)=11.*PSI(5)                                  (L 21)
   PSI(11)=PSI(19)=13.*PSI(5)                                  (L 22)
   PSI(12)=PSI(20)=15.*PSI(5)                                  (L 23)
1 READ (5,900) LI,ZETA1,ETA1,GAMMA,SIGMA,BETA4,ALPHA4,ALPHAB, (L 24)
1   LRR,HRR,ALPHAR                                             (L 25)
   IF (EOF,5) 999,47                                           (L 26)
47 AALPF=ALPHA4                                                (L 27)
   AALPR=ALPHAR                                                 (L 28)
   AALPB=ALPHAB                                                 (L 29)
   ABETA=BETA4                                                  (L 30)
   ALPHA4=ALPHA4*RAD                                           (L 31)
   ALPHAR=ALPHAR*RAD                                           (L 32)
   ALPHAB=ALPHAB*RAD                                           (L 33)
   BETA4=BETA4*RAD                                             (L 34)
   WRITE (6,100)                                               (L 35)
   SUML=.0025                                                  (L 36)
   IF (LI.EQ.1) GO TO 804                                       (L 37)
   IALPHA=10HTRIANGULAR                                         (L 38)
   DO 808 M2=1,20                                              (L 39)
808 XLOAD(M2)=RTRIA(M2)                                         (L 40)
   GO TO 160                                                    (L 41)
804 IALPHA=10HUNIFORM                                           (L 42)
   DO 809 M2=1,20                                              (L 43)
809 XLOAD(M2)=RUNIF(M2)                                         (L 44)
160 NROT=4                                                      (L 45)
   IF (SIGMA.EQ.0.) NROT=1                                       (L 46)
   DO 42 ITR=1,NROT                                           (L 47)
   WRITE (6,701)                                               (L 48)
   GO TO (601,602,603,604), ITR                                (L 49)
601 IF (SIGMA.EQ.0.) WRITE (6,707)                             (L 50)
   IF (SIGMA.EQ.0.) GO TO 610                                   (L 51)
   WRITE (6,702)                                               (L 52)
   GO TO 610                                                    (L 53)
602 WRITE (6,703)                                              (L 54)
   GO TO 610                                                    (L 55)

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# Appendix L – Continued

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603 WRITE (6,704) (L 56)
GO TO 610 (L 57)
604 WRITE (6,705) (L 58)
610 WRITE (6,706) IALPHA,GAMMA,SIGMA,LRR,AALPF,AALPB,ZETA1,ETA1, (L 59)
1 HRR,AALPR,ABETA (L 60)
WRITE (6,210) (L 61)
WRITE (6,211) (L 62)
WRITE (6,212) (L 63)
WRITE (6,213) (L 64)
WRITE (6,214) (L 65)
WRITE (6,215) (L 66)
WRITE (6,216) (L 67)
WRITE (6,217) (L 68)
WRITE (6,218) (L 69)
DO 41 K=1,8 (L 70)
M7=N7=20 (L 71)
IF (SIGMA.NE.0.) GO TO 815 (L 72)
M7=N7=1 (L 73)
CONST1=400. (L 74)
GO TO 812 (L 75)
815 IF (ETA1.NE.1..OR.ABETA.NE.0.) GO TO 813 (L 76)
CONST1=2. (L 77)
GO TO 812 (L 78)
813 CONST1=1. (L 79)
812 CO 801 M1=1,M7 (L 80)
DO 802 N1=1,N7 (L 81)
IF (ETA1.NE.1..OR.ABETA.NE.0.) GO TO 811 (L 82)
IF (PSI(N1).GT.PI) GO TO 802 (L 83)
811 GO TO (621,622,623,624), ITR (L 84)
621 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1))*COS(BETA)+ (L 85)
1 COS(PSI(N1))*COS(ALPHA)*SIN(BETA)) (L 86)
ZETA=ZETA1/(1.0-XLOAD(N1)*SIGMA*GAMMA*ZETA1*COS(PSI(N1)) (L 87)
1 *SIN(ALPHA)) (L 88)
XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(PSI(M1))*COS(ALPHA)*COS(BETA) (L 89)
1 -SIN(PSI(M1))*SIN(BETA))-XLOAD(N1)*(COS(PSI(N1))*COS(ALPHA) (L 90)
2 *COS(BETA)-SIN(PSI(N1))*SIN(BETA)) (L 91)
YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(PSI(M1))*COS(BETA)+COS(PSI (L 92)
1 (M1))*COS(ALPHA)*SIN(BETA))-XLOAD(N1)*(SIN(PSI(N1))* (L 93)
2 COS(BETA)-COS(PSI(N1))*COS(ALPHA)*SIN(BETA)) (L 94)
ZOVERH=-SIGMA*GAMMA*SIN(ALPHA)*(XLOAD(M1)*COS(PSI(M1))- (L 95)
1 XLOAD(N1)*COS(PSI(N1))) (L 96)
GO TO 630 (L 97)
622 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1))*COS(BETA)+COS(PSI(N1))* (L 98)
1 COS(ALPHA)*SIN(BETA))-SIGMA*SIN(BETA)*(LRR*COS(ALPHA)+ (L 99)
2 HRR*SIN(ALPHA)) (L 100)
ZETA=ZETA1/(1.0-SIGMA*GAMMA*ZETA1*(XLOAD(N1)*COS(PSI(N1))* (L 101)
1 SIN(ALPHA)+LRR*SIN(ALPHA)-HRR*COS(ALPHA)) (L 102)
XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(PSI(M1))*COS(ALPHA)*COS (L 103)
1 (BETA)-SIN(PSI(M1))*SIN(BETA))-XLOAD(N1)*(COS(PSI(N1))* (L 104)
2 COS(ALPHA)*COS(BETA)-SIN(PSI(N1))*SIN(BETA))-COS(BETA)* (L 105)
3 (LRR*COS(ALPHA)+HRR*SIN(ALPHA)) (L 106)
YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(PSI(M1))*COS(BETA)+ (L 107)
1 COS(PSI(M1))*COS(ALPHA)*SIN(BETA))-XLOAD(N1)*(SIN(PSI(N1)) (L 108)
2 *COS(BETA)+COS(PSI(N1))*COS(ALPHA)*SIN(BETA))-SIN(BETA)* (L 109)
3 (LRR*COS(ALPHA)+HRR*SIN(ALPHA)) (L 110)
ZOVERH=-SIGMA*GAMMA*(XLOAD(M1)*COS(PSI(M1))*SIN(ALPHA)- (L 111)
1 XLOAD(N1)*COS(PSI(N1))*SIN(ALPHA)-LRR*SIN(ALPHA)+ (L 112)
2 HRR*COS(ALPHA)) (L 113)
GO TO 630 (L 114)
623 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1))*COS(BETA)+COS(PSI(N1)) (L 115)
1 *COS(ALPHA)*SIN(BETA))-SIGMA*SIN(BETA)*(LRR*COS(ALPHA) (L 116)

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# Appendix L - Continued

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2      +HRR*SIN(ALPHAB))                                (L 117)
ZETA=ZETA1/(1.0-SIGMA*GAMMA*ZETA1*(XLOAD(N1)*COS(PSI(N1))*SIN (L 118)
1      (ALPHAR)+LRR*SIN(ALPHAB)-HRR*COS(ALPHAB)))      (L 119)
XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(PSI(M1))*COS(ALPHAR)*COS (L 120)
1      (BETA)-SIN(PSI(M1))*SIN(BETA))-XLOAD(N1)*(COS(PSI(N1))* (L 121)
2      COS(ALPHAR)*COS(BETA)-SIN(PSI(N1))*SIN(BETA)))    (L 122)
YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(PSI(M1))*COS(BETA)+COS (L 123)
1      (PSI(M1))*COS(ALPHAR)*SIN(BETA))-XLOAD(N1)*(SIN(PSI(N1)) (L 124)
2      *COS(BETA)+COS(PSI(N1))*COS(ALPHAR)*SIN(BETA)))  (L 125)
ZOVERH=-SIGMA*GAMMA*SIN(ALPHAR)*(XLOAD(M1)*COS(PSI(M1))- (L 126)
1      XLOAD(N1)*COS(PSI(N1)))                            (L 127)
GO TO 630                                                (L 128)
624 ETA=ETA1-XLOAD(N1)*SIGMA*(SIN(PSI(N1))*COS(BETA)+COS(PSI(N1))* (L 129)
1      COS(ALPHAF)*SIN(BETA))                            (L 130)
ZETA=ZETA1/(1.0-XLOAD(N1)*SIGMA*GAMMA*ZETA1*COS(PSI(N1))* (L 131)
1      SIN(ALPHAF))                                       (L 132)
XOVERH=SIGMA*GAMMA*(XLOAD(M1)*(COS(PSI(M1))*COS(ALPHAR)*COS (L 133)
1      (BETA)-SIN(PSI(M1))*SIN(BETA))+COS(BETA)*(LRR*COS(ALPHAB) (L 134)
2      +HRR*SIN(ALPHAB))-XLOAD(N1)*(COS(PSI(N1))*COS(ALPHAF)* (L 135)
3      COS(BETA)-SIN(PSI(N1))*SIN(BETA)))               (L 136)
YOVERH=SIGMA*GAMMA*(XLOAD(M1)*(SIN(PSI(M1))*COS(BETA)+COS(PSI (L 137)
1      (M1))*COS(ALPHAR)*SIN(BETA))+SIN(BETA)*(LRR*COS(ALPHAB)+ (L 138)
2      HRR*SIN(ALPHAB))-XLOAD(N1)*(SIN(PSI(N1))*COS(BETA)+ (L 139)
3      COS(PSI(N1))*COS(ALPHAF)*SIN(BETA)))             (L 140)
ZOVERH=-SIGMA*GAMMA*(XLOAD(M1)*COS(PSI(M1))*SIN(ALPHAR)+ (L 141)
1      LRR*SIN(ALPHAB)-HRR*COS(ALPHAB)-XLOAD(N1)*COS(PSI(N1))* (L 142)
2      SIN(ALPHAF))                                       (L 143)
630 CALL DLTAS (C(K))                                    (L 144)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
DO 805 L1=1,28                                          (L 145)
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)                    (L 146)
802 CONTINUE                                           (L 147)
801 CONTINUE                                           (L 148)
DO 807 L3=1,28                                          (L 149)
807 DELTA(L3)=XDELTA(L3)*SUML*CONST1                   (L 150)
DO 500 LL=1,28                                          (L 151)
500 DELTA(LL)=DELTA(LL)*PI*(SIGMA**2)*GAMMA/4.0       (L 152)
WRITE (6,149) C(K)                                     (L 153)
WRITE (6,150) (DELTA(I),I=1,25,4)                     (L 154)
WRITE (6,151) (DELTA(I),I=2,26,4)                     (L 155)
WRITE (6,152) (DELTA(I),I=3,27,4)                     (L 156)
WRITE (6,153) (DELTA(I),I=4,28,4)                     (L 157)
DO 814 L4=1,28                                          (L 158)
814 XDELTA(L4)=0.                                       (L 159)
41 CONTINUE                                           (L 160)
42 CONTINUE                                           (L 161)
GO TO 1                                                (L 162)
100 FORMAT (1H1/////////59X*START NEW CASE*)          (L 163)
149 FORMAT (1X*CHI =* F7.3/)                           (L 164)
150 FORMAT (3X5H(W,L)7(F17.4))                        (L 165)
151 FORMAT (3X5H(U,L)7(F17.4))                        (L 166)
152 FORMAT (3X5H(W,D)7(F17.4))                        (L 167)
153 FORMAT (3X5H(U,D)7(F17.4)///)                     (L 168)
210 FORMAT (1X131(1H-))                                (L 169)
211 FORMAT (1X1H111X1H131X61HCORRECTION FACTORS FOR CORRECTING FROM A (L 170)
1WIND TUNNEL WHICH IS25X1HI)                          (L 171)
212 FORMAT (1X1H111X1H117(1H-)1HI)                   (L 172)
213 FORMAT (1X1H111X1H116X1H15X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (L 173)
1H16X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI)              (L 174)
214 FORMAT (1X1H13X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (L 175)
1EN6X1HI6X4HONLY6X1HI5X6HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1HI (L 176)

```

# Appendix L – Concluded

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211) (L 177)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 16X4H (L 178)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (L 179)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (L 180)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (L 181)
1HI) (L 182)
218 FORMAT (1X131(1H-)/) (L 183)
701 FORMAT (1H1//41X*AVERAGE WIND-TUNNEL INTERFERENCE OVER TANDEM ROTO (L 184)
IRS*/) (L 185)
702 FORMAT (49X*EFFECT OF FRCNT ROTOR ON FRONT ROTOR*//) (L 186)
703 FORMAT (49X*EFFECT OF REAR ROTOR ON FRONT ROTOR*//) (L 187)
704 FORMAT (48X*EFFECT OF REAR ROTOR ON REAR ROTOR*//) (L 188)
705 FORMAT (49X*EFFECT OF FRCNT ROTOR ON REAR ROTOR*//) (L 189)
706 FORMAT (58XA10* LOADING*//6X*GAMMA ==F7.3,10X*SIGMA ==F6.3, (L 190)
110X*L(RR)/R ==F6.3,10X*ALPHA(FR) ==F8.3,10X*ALPHA(BODY) == (L 191)
2F8.3//6X*ZETA ==F7.3,10X*ETA ==F6.3,10X*H(RR)/R ==F6.3, (L 192)
310X*ALPHA(RR) ==F8.3,14X*BETA ==F8.3//) (L 193)
707 FORMAT (26X*FOR SIGMA = 0, THE EFFECTS OF THE FRCNT ROTOR ON THE F (L 194)
1RCNT ROTOR, THE REAR ROTOR*/26X*ON THE FRONT ROTOR, THE REAR ROTOR (L 195)
2 ON THE REAR ROTOR, AND THE FRONT ROTOR ON THE*/39X*REAR ROTOR ARE (L 196)
3 ALL IDENTICAL, AND ARE GIVEN AS FOLLOWS,*//) (L 197)
900 FORMAT (11,F9.3,6F10.3/3F10.3) (L 198)
999 STOP (L 199)
END (L 200)

```

## APPENDIX M

-----

### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER UNLOADED-ROTOR CONFIGURATIONS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (TWO CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES FOR THE ROTOR, ON THE FIRST CARD, ARE

LIR	ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHAR	ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE

LIW	WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW	DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW	DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG
ALPHAB	ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG



## Appendix M – Continued

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS.

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE ON THE WING AND ROTOR DUE TO THEIR OWN PRESENCE, AS WELL AS THE INTERFERENCE ON EACH DUE TO THE PRESENCE OF THE OTHER.

```

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)           (M 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)             (M 2)
DIMENSION XDELTA(28),PSI(20),RLOAD(20),RUNIF(20),RTRIA(20),      (M 3)
1 XLE(10),XLOAD(20),C(8)                                          (M 4)
REAL LAMBDA,LW                                                    (M 5)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/             (M 6)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/              (M 7)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./             (M 8)
PI=3.14159265358979                                              (M 9)
RAD=0.0174532925199                                              (M 10)
DO 803 L1=1,28                                                    (M 11)
803 XDELTA(L1)=0.                                                 (M 12)
PSI(1)=(PI/4.)                                                    (M 13)
PSI(2)=3.*PSI(1)                                                  (M 14)
PSI(3)=5.*PSI(1)                                                  (M 15)
PSI(4)=7.*PSI(1)                                                  (M 16)
PSI(5)=PSI(13)=(PI/8.)                                           (M 17)
PSI(6)=PSI(14)=3.*PSI(5)                                          (M 18)
PSI(7)=PSI(15)=5.*PSI(5)                                          (M 19)
PSI(8)=PSI(16)=7.*PSI(5)                                          (M 20)
PSI(9)=PSI(17)=9.*PSI(5)                                          (M 21)
PSI(10)=PSI(18)=11.*PSI(5)                                        (M 22)
PSI(11)=PSI(19)=13.*PSI(5)                                        (M 23)
PSI(12)=PSI(20)=15.*PSI(5)                                        (M 24)
XLE(1)=XLE(10)=0.43579                                           (M 25)
XLE(2)=XLE(9) =0.71422                                           (M 26)
XLE(3)=XLE(8) =0.86603                                           (M 27)
XLE(4)=XLE(7) =0.95394                                           (M 28)
XLE(5)=XLE(6) =0.99499                                           (M 29)
1 READ (5,900) LIR,ZETA1,ETA1,GAMMA,SIGMAR,ALPHAR,LIW,LW,HW,    (M 30)
1 SIGMAW,LAMBDA,ALPHAB                                           (M 31)
IF (EOF,5) 999,47                                                 (M 32)
47 AALPR=ALPHAR                                                    (M 33)
AALPB=ALPHAB                                                       (M 34)
ALAM=LAMBDA                                                        (M 35)
LAMBDA=LAMBDA*RAD                                                  (M 36)
ALPHAR=ALPHAR*RAD                                                  (M 37)
ALPHAB=ALPHAB*RAD                                                  (M 38)
WRITE (6,100)                                                      (M 39)
IF (LIR.EQ.1) GO TO 804                                           (M 40)
IALPHA=10HTRIANGULAR                                              (M 41)
DO 808 M2=1,20                                                    (M 42)
808 RLOAD(M2)=RTRIA(M2)                                           (M 43)
GO TO 806                                                          (M 44)
804 IALPHA=10HUNIFORM                                             (M 45)
DO 809 M2=1,20                                                    (M 46)
809 RLOAD(M2)=RTRIA(M2)                                           (M 47)
806 IF (LIW.EQ.1) GO TO 852                                        (M 48)
IBETA=8HELLIPTIC                                                  (M 49)
DO 851 M3=1,10                                                    (M 50)
851 XLOAD(M3)=XLE(M3)                                             (M 51)

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# Appendix M - Continued

	GO TO 850	(M 52)
852	IBETA=8+UNIFORM	(M 53)
	DO 853 M3=1,10	(M 54)
853	XLOAD(M3)=1.0	(M 55)
850	IF (SIGMAR.NE.0.) GO TO 855	(M 56)
	WRITE (6,701)	(M 57)
	WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,	(M 58)
1	HW,AALPB,GAMMA,ALAM	(M 59)
	WRITE (6,210)	(M 60)
	WRITE (6,211)	(M 61)
	WRITE (6,212)	(M 62)
	WRITE (6,213)	(M 63)
	WRITE (6,214)	(M 64)
	WRITE (6,215)	(M 65)
	WRITE (6,216)	(M 66)
	WRITE (6,217)	(M 67)
	WRITE (6,218)	(M 68)
	WRITE (6,707)	(M 69)
	GO TO 1	(M 70)
855	DO 42 IELEM=1,4	(M 71)
	WRITE (6,701)	(M 72)
	GO TO (601,602,603,604), IELEM	(M 73)
601	WRITE (6,702)	(M 74)
	GO TO 610	(M 75)
602	WRITE (6,703)	(M 76)
	GO TO 610	(M 77)
603	WRITE (6,704)	(M 78)
	GO TO 610	(M 79)
604	WRITE (6,705)	(M 80)
610	WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,	(M 81)
1	HW,AALPB,GAMMA,ALAM	(M 82)
	WRITE (6,210)	(M 83)
	WRITE (6,211)	(M 84)
	WRITE (6,212)	(M 85)
	WRITE (6,213)	(M 86)
	WRITE (6,214)	(M 87)
	WRITE (6,215)	(M 88)
	WRITE (6,216)	(M 89)
	WRITE (6,217)	(M 90)
	WRITE (6,218)	(M 91)
	DO 41 K=1,8	(M 92)
	M7=N7=20	(M 93)
	GO TO (611,612,613,614), IELEM	(M 94)
C		(M 95)
C	ROTOR ON ROTOR	(M 96)
C		(M 97)
611	SUML=0.0025	(M 98)
	IF (ETA1.EQ.1.) SUML=0.005	(M 99)
	GO TO 812	(M 100)
C		(M 101)
C	WING ON ROTOR	(M 102)
C		(M 103)
612	SUML=0.0063052	(M 104)
	IF (SIGMAW.EQ.0.) GO TO 615	(M 105)
	IF (LIW.EQ.1) SUML=0.005	(M 106)
	N7=10	(M 107)
	IF (ETA1.NE.1.) GO TO 812	(M 108)
	SUML=0.0126104	(M 109)
	IF (LIW.EQ.1) SUML=0.010	(M 110)
	N7=5	(M 111)
	GO TO 812	(M 112)

# Appendix M – Continued

615	SUML=0.05	(M 113)
	N7=1	(M 114)
	XLOAD(1)=1.0	(M 115)
	IF (ETA1.EQ.1.) SUML=0.10	(M 116)
	GO TO 812	(M 117)
C		(M 118)
C	WING ON WING	(M 119)
C		(M 120)
613	SUML=0.0126104	(M 121)
	IF (SIGMAW.EQ.0.) GO TO 616	(M 122)
	IF (LIW.EQ.1) SUML=0.010	(M 123)
	M7=10	(M 124)
	N7=10	(M 125)
	IF (ETA1.NE.1.) GO TO 812	(M 126)
	SUML=0.0252208	(M 127)
	IF (LIW.EQ.1) SUML=0.020	(M 128)
	N7=5	(M 129)
	GO TO 812	(M 130)
616	SUML=1.	(M 131)
	XLOAD(1)=1.0	(M 132)
	M7=N7=1	(M 133)
	GO TO 812	(M 134)
C		(M 135)
C	ROTOR ON WING	(M 136)
C		(M 137)
614	SUML=0.0050	(M 138)
	IF (ETA1.EQ.1.) SUML=0.010	(M 139)
	M7=10	(M 140)
	IF (SIGMAW.NE.0.) GO TO 812	(M 141)
	M7=1	(M 142)
	SUML=0.05	(M 143)
	IF (ETA1.EQ.1.) SUML=0.10	(M 144)
812	DO 801 M1=1,M7	(M 145)
	DO 802 N1=1,N7	(M 146)
	XSTAR=(11.-2.*FLOAT(M1))/10.	(M 147)
	YSTAR=(11.-2.*FLOAT(N1))/10.	(M 148)
811	GO TO (621,622,623,624), IELEM	(M 149)
C		(M 150)
C	ROTOR ON ROTOR	(M 151)
C		(M 152)
621	IF (ETA1.NE.1.) GO TO 625	(M 153)
	IF (PSI(N1).GT.PI) GO TO 802	(M 154)
625	ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))	(M 155)
	ZETA=ZETA1/(1.0-RLOAD(N1)*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))	(M 156)
	1 *SIN(ALPHAR))	(M 157)
	XCOVERH=SIGMAR*GAMMA*COS(ALPHAR)*(RLOAD(M1)*COS(PSI(M1))	(M 158)
	1 -RLOAD(N1)*COS(PSI(N1)))	(M 159)
	YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))-RLOAD(N1)*SIN(PSI(N1))	(M 160)
	1 )	(M 161)
	ZOVERH=-SIGMAR*GAMMA*SIN(ALPHAR)*(RLOAD(M1)*COS(PSI(M1))	(M 162)
	1 -RLOAD(N1)*COS(PSI(N1)))	(M 163)
	XLOAD(N1)=1.0	(M 164)
	GO TO 630	(M 165)
C		(M 166)
C	WING ON ROTOR	(M 167)
C		(M 168)
622	IF (ETA1.NE.1..OR.SIGMAW.NE.0.) GO TO 627	(M 169)
	IF (PSI(M1).GT.PI) GO TO 802	(M 170)
627	ETA=ETA1-YSTAR*SIGMAW	(M 171)
	ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR)	(M 172)
	1 *TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)))	(M 173)

# Appendix M - Continued

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XOVERH=SIGMAR*GAMMA*(RLOAD(M1)*COS(ALPHAR)*COS(PSI(M1))      (M 174)
1  -ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*COS(ALPHAB)      (M 175)
2  -LW*COS(ALPHAB)-HW*SIN(ALPHAB))      (M 176)
YOVERH=SIGMAR*GAMMA*(RLOAD(M1)*SIN(PSI(M1))-YSTAR*(SIGMAW/    (M 177)
1  SIGMAR))      (M 178)
ZOVERH=-SIGMAR*GAMMA*(RLOAD(M1)*SIN(ALPHAR)*COS(PSI(M1))      (M 179)
1  -ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*SIN(ALPHAB)      (M 180)
2  -LW*SIN(ALPHAB)+HW*COS(ALPHAB))      (M 181)
GO TO 630      (M 182)
C      (M 183)
C      WING ON WING      (M 184)
C      (M 185)
623 ETA=ETA1-SIGMAW*YSTAR      (M 186)
ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR) (M 187)
1  *TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB))) (M 188)
XOVERH=SIGMAW*GAMMA*TAN(LAMBDA)*COS(ALPHAB)*(ABS(XSTAR)      (M 189)
1  -ABS(YSTAR))      (M 190)
YOVERH=0.2*SIGMAW*GAMMA*(FLOAT(N1)-FLOAT(M1))      (M 191)
ZOVERH=-SIGMAW*GAMMA*TAN(LAMBDA)*SIN(ALPHAB)*(ABS(XSTAR)      (M 192)
1  -ABS(YSTAR))      (M 193)
GO TO 630      (M 194)
C      (M 195)
C      ROTOR ON WING      (M 196)
C      (M 197)
624 IF (ETA1.NE.1.) GO TO 626      (M 198)
IF (PSI(N1).GT.PI) GO TO 802      (M 199)
626 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))      (M 200)
ZETA=ZETA1/(1.0-RLOAD(N1)*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))      (M 201)
1  *SIN(ALPHAR))      (M 202)
XOVERH=SIGMAR*GAMMA*(ABS(XSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)* (M 203)
1  COS(ALPHAB)+LW*COS(ALPHAB)+HW*SIN(ALPHAB)-RLOAD(N1)*      (M 204)
2  COS(ALPHAR)*COS(PSI(N1)))      (M 205)
YOVERH=SIGMAR*GAMMA*(XSTAR*(SIGMAW/SIGMAR)-RLOAD(N1)*SIN(PSI(N1))) (M 206)
ZOVERH=-SIGMAR*GAMMA*(ABS(XSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)* (M 207)
1  SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)-RLOAD(N1)*      (M 208)
2  SIN(ALPHAR)*COS(PSI(N1)))      (M 209)
XLOAD(N1)=1.0      (M 210)
630 CALL DLTAS (C(K))      (M 211)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
DC 8C5 L1=1,28      (M 212)
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)      (M 213)
802 CONTINUE      (M 214)
801 CONTINUE      (M 215)
DO 807 L3=1,28      (M 216)
807 DELTA(L3)=XDELTA(L3)*SUML      (M 217)
WRITE (6,149) C(K)      (M 218)
WRITE (6,150) (DELTA(I),I=1,25,4)      (M 219)
WRITE (6,151) (DELTA(I),I=2,26,4)      (M 220)
WRITE (6,152) (DELTA(I),I=3,27,4)      (M 221)
WRITE (6,153) (DELTA(I),I=4,28,4)      (M 222)
DO 814 L4=1,28      (M 223)
814 XDELTA(L4)=0.      (M 224)
41 CONTINUE      (M 225)
42 CONTINUE      (M 226)
GO TO 1      (M 227)
100 FORMAT (1H1/////////59X*START NEW CASE*)      (M 228)
149 FORMAT (1X*CHI =* F7.3/)      (M 229)
150 FORMAT (3X5H(W,L)7(F17.4))      (M 230)
151 FORMAT (3X5H(U,L)7(F17.4))      (M 231)
152 FORMAT (3X5H(W,D)7(F17.4))      (M 232)
153 FORMAT (3X5H(U,D)7(F17.4)//)      (M 233)

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# Appendix M - Concluded

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210 FORMAT (1X131(1H-)) (M 234)
211 FORMAT (1X1HI11X1HI31X61H CORRECTION FACTORS FOR CORRECTING FROM A (M 235)
      1 WIND TUNNEL WHICH IS 25X1HI) (M 236)
212 FORMAT (1X1HI11X1HI117(1H-))1HI) (M 237)
213 FORMAT (1X1HI11X1HI16X1HI5X6H CLOSED5X1HI16X1HI2X12H CLOSED FLOOR2X1 (M 238)
      1HI6X4H OPEN6X1HI16X1HI5X6H CLOSED4X1HI) (M 239)
214 FORMAT (1X1HI3X5H DELTA43X1HI5X6H CLOSED5X1HI4X9H ON BOTTOM3X1HI6X4H OP (M 240)
      1EN6X1HI6X4H ONLY6X1HI5X5H FLOOR6X1HI5X6H CLOSED5X1HI3X9H ON BOTTOM3X1H (M 241)
      2I) (M 242)
215 FORMAT (1X1HI11X1HI16X1HI6X4H ONLY6X1HI16X18HI(GROUND EFFECT) ISX4H (M 243)
      1ONLY6X1HI16X1HI6X4H ONLY5X1HI) (M 244)
216 FORMAT (1X1HI11X1HI84(1H-))1HI32(1H-))1HI) (M 245)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (M 246)
      1HI) (M 247)
218 FORMAT (1X131(1H-)) (M 248)
701 FORMAT (1H1//42X*AVERAGE INTERFERENCE OVER AN UNLOADED ROTOR MODEL (M 249)
      1*/) (M 250)
702 FORMAT (54X*EFFECT OF RCTOR ON ROTOR*//) (M 251)
703 FORMAT (55X*EFFECT OF WING ON ROTOR*//) (M 252)
704 FORMAT (55X*EFFECT OF WING ON WING*//) (M 253)
705 FORMAT (55X*EFFECT OF ROTOR ON WING*//) (M 254)
706 FORMAT (34X,A10* ROTOR LOADING*19X,A8* WING LOADING*// (M 255)
      119X*SIGMA(ROTOR) =*F6.3,10X*ZETA =*F6.3,10X*LW/R =*F6.3,13X (M 256)
      2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING) =*F6.3,10X*ETA =*F6.3, (M 257)
      310X*HW/R =*F6.3,10X*ALPHA(BODY) =*F7.3//39X*GAMMA =*F6.3, (M 258)
      427X*LAMBDA =*F7.3//) (M 259)
707 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE (M 260)
      1 FOR USE WITH SUCH CASES.*//) (M 261)
900 FORMAT (11,F9.3,4F10.3/11,F9.3,4F10.3) (M 262)
999 STOP (M 263)
      END (M 264)

```

## APPENDIX N

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### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND AN UNLOADED-ROTOR CONFIGURATION

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (THREE CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN TO BE AT THE CENTER OF THE ROTOR. THE REQUIRED INPUT VARIABLES FOR THE ROTOR, ON THE FIRST CARD, ARE

LIR	ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
ALPHAR	ANGLE OF ATTACK OF ROTOR TIP-PATH PLANE, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE

LIW	WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW	DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
FW	DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG

# Appendix N - Continued

ALPHAB ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, ON THE THIRD CARD, ARE

SIGMAT RATIO OF TAIL SPAN TO TUNNEL WIDTH

TL TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS

TH TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS.

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT THE TAIL DUE TO THE PRESENCE OF BOTH THE WING AND THE ROTOR.

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PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)      (N 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)         (N 2)
DIMENSION XDELTA(28),PSI(20),RLOAD(20),RUNIF(20),RTRIA(20),  (N 3)
1      XLE(10),XLOAD(20),C(8)                                  (N 4)
REAL LAMBDA,LW                                                (N 5)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/         (N 6)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/         (N 7)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./         (N 8)
PI=3.14159265358979                                          (N 9)
RAD=0.0174532925199                                          (N 10)
DO 803 L1=1,28                                                (N 11)
803 XDELTA(L1)=0.                                             (N 12)
PSI(1)=(PI/4.)                                               (N 13)
PSI(2)=3.*PSI(1)                                             (N 14)
PSI(3)=5.*PSI(1)                                             (N 15)
PSI(4)=7.*PSI(1)                                             (N 16)
PSI(5)=PSI(13)=(PI/8.)                                       (N 17)
PSI(6)=PSI(14)=3.*PSI(5)                                     (N 18)
PSI(7)=PSI(15)=5.*PSI(5)                                     (N 19)
PSI(8)=PSI(16)=7.*PSI(5)                                     (N 20)
PSI(9)=PSI(17)=9.*PSI(5)                                     (N 21)
PSI(10)=PSI(18)=11.*PSI(5)                                   (N 22)
PSI(11)=PSI(19)=13.*PSI(5)                                   (N 23)
PSI(12)=PSI(20)=15.*PSI(5)                                   (N 24)
XLE(1)=XLE(10)=0.43579                                       (N 25)
XLE(2)=XLE(9) =0.71422                                       (N 26)
XLE(3)=XLE(8) =0.86603                                       (N 27)
XLE(4)=XLE(7) =0.95394                                       (N 28)
XLE(5)=XLE(6) =0.99499                                       (N 29)
1 READ (5,900) LIR,ZETA1,ETA1,GAMMA,SIGMAR,ALPHAR,LIW,LW,HW, (N 30)
1      SIGMAW,LAMBDA,ALPHAB,SIGMAT,TL,TH                     (N 31)
IF (EOF,5) 999,47                                           (N 32)
47 AALPR=ALPHAR                                              (N 33)
AALPB=ALPHAB                                                 (N 34)
ALAM=LAMBDA                                                  (N 35)
LAMBDA=LAMBDA*RAD                                            (N 36)
ALPHAR=ALPHAR*RAD                                            (N 37)

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# Appendix N - Continued

ALPHAB=ALPHAB*RAO	(N 38)
WRITE (6,100)	(N 39)
IF (LIR.EQ.1) GO TO 804	(N 40)
IALPHA=10HTRIANGULAR	(N 41)
CC 808 M2=1,20	(N 42)
808 RLOAD(M2)=RTRIA(M2)	(N 43)
GC TO 806	(N 44)
804 IALPHA=10HUNIFORM	(N 45)
DO 809 M2=1,20	(N 46)
809 RLOAD(M2)=RTRIA(M2)	(N 47)
806 IF (LIW.EQ.1) GO TO 852	(N 48)
IBETA=8FELLIPTIC	(N 49)
DO 851 M3=1,10	(N 50)
851 XLOAD(M3)=XLE(M3)	(N 51)
GO TO 850	(N 52)
852 IBETA=8FUNIFORM	(N 53)
DO 853 M3=1,10	(N 54)
853 XLOAD(M3)=1.0	(N 55)
850 IF (SIGMAR.NE.0.) GO TO 855	(N 56)
WRITE (6,701)	(N 57)
WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,	(N 58)
1 HW,AALPB,SIGMAT,TL,TH,GAMMA,ALAM	(N 59)
WRITE (6,210)	(N 60)
WRITE (6,211)	(N 61)
WRITE (6,212)	(N 62)
WRITE (6,213)	(N 63)
WRITE (6,214)	(N 64)
WRITE (6,215)	(N 65)
WRITE (6,216)	(N 66)
WRITE (6,217)	(N 67)
WRITE (6,218)	(N 68)
WRITE (6,707)	(N 69)
GO TO 1	(N 70)
855 DO 42 IELEM=1,2	(N 71)
WRITE (6,701)	(N 72)
GO TO (601,602), IELEM	(N 73)
601 WRITE (6,702)	(N 74)
GO TO 610	(N 75)
602 WRITE (6,703)	(N 76)
610 WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,	(N 77)
1 HW,AALPB,SIGMAT,TL,TH,GAMMA,ALAM	(N 78)
WRITE (6,210)	(N 79)
WRITE (6,211)	(N 80)
WRITE (6,212)	(N 81)
WRITE (6,213)	(N 82)
WRITE (6,214)	(N 83)
WRITE (6,215)	(N 84)
WRITE (6,216)	(N 85)
WRITE (6,217)	(N 86)
WRITE (6,218)	(N 87)
DO 41 K=1,8	(N 88)
N7=20	(N 89)
M7=4	(N 90)
GO TO (611,613), IELEM	(N 91)
C	(N 92)
C EFFECT OF ROTOR	(N 93)
C	(N 94)
611 SUML=0.0125	(N 95)
IF (ETA1.EQ.1.) SUML=0.025	(N 96)
IF (SIGMAT.NE.0.) GO TO 812	(N 97)
SUML=C.050	(N 98)



# Appendix N - Continued

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      IF (ETA1.EQ.1.)  SUML=C.100                      (N 99)
      M7=1                                                  (N 100)
      GO TO 812                                           (N 101)
C
C      EFFECT OF WING                                     (N 102)
C                                                         (N 103)
C                                                         (N 104)
613  SUML=0.031526                                       (N 105)
      IF (SIGMAW.EQ.0..OR.SIGMAT.EQ.0.)  GO TO 616       (N 106)
      IF (LIW.EQ.1)  SUML=0.025                         (N 107)
      M7=4                                                (N 108)
      N7=10                                              (N 109)
      IF (ETA1.NE.1.)  GO TO 812                       (N 110)
      SUML=0.063052                                       (N 111)
      IF (LIW.EQ.1)  SUML=0.050                         (N 112)
      N7=5                                                (N 113)
      GO TO 812                                           (N 114)
616  IF (SIGMAW.EQ.0..AND.SIGMAT.NE.0.)  GO TO 612      (N 115)
      IF (SIGMAW.NE.0..AND.SIGMAT.EQ.0.)  GO TO 614      (N 116)
      SUML=1.0                                           (N 117)
      XLOAD(1)=1.0                                       (N 118)
      M7=N7=1                                           (N 119)
      GO TO 812                                           (N 120)
612  SUML=0.025                                         (N 121)
      M7=4                                                (N 122)
      N7=1                                                (N 123)
      XLOAD(1)=1.0                                       (N 124)
      IF (ETA1.NE.1.)  GO TO 812                       (N 125)
      M7=2                                                (N 126)
      SUML=0.50                                           (N 127)
      GO TO 812                                           (N 128)
614  SUML=0.126104                                       (N 129)
      IF (LIW.EQ.1)  SUML=0.100                         (N 130)
      N7=10                                              (N 131)
      M7=1                                                (N 132)
      IF (ETA1.NE.1.)  GO TO 812                       (N 133)
      SUML=0.25208                                       (N 134)
      IF (LIW.EQ.1)  SUML=0.200                         (N 135)
      N7=5                                                (N 136)
812  DO 801  M1=1,M7                                     (N 137)
      DO 802  N1=1,N7                                     (N 138)
      XSTAR=(11.-2.*FLOAT(M1))/10.                     (N 139)
      YSTAR=(11.-2.*FLOAT(N1))/10.                     (N 140)
      GO TO (621,622), IELEM                             (N 141)
C                                                         (N 142)
C      EFFECT OF ROTOR                                   (N 143)
C                                                         (N 144)
C                                                         (N 145)
621  ETA=ETA1-RLJAD(N1)*SIGMAR*SIN(PSI(N1))           (N 146)
      ZETA=ZETA1/(1.0-RLOAD(N1))*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))*
1    SIN(ALPHAR))                                       (N 147)
      XOVERH=SIGMAR*GAMMA*(TL*COS(ALPHAB)+TH*SIN(ALPHAB)-RLOAD(N1)*
1    COS(ALPHAB)*COS(PSI(N1)))                         (N 149)
      YOVERH=SIGMAR*GAMMA*(0.25*(5.0-2.0*FLOAT(M1))*(SIGMAT/SIGMAR)-
1    RLOAD(N1)*SIN(PSI(N1)))                           (N 150)
      ZOVERH=SIGMAR*GAMMA*(TH*COS(ALPHAB)-TL*SIN(ALPHAB)+RLOAD*
1    SIN(ALPHAB)*COS(PSI(N1)))                         (N 152)
      XLOAD(N1)=1.0                                       (N 154)
      GO TO 630                                           (N 155)
C                                                         (N 156)
C      EFFECT OF WING                                     (N 157)
C                                                         (N 158)
C                                                         (N 159)
622  ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR)

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# Appendix N - Concluded

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1      *TAN(LAMBDA)*SIN(ALPHAB)+LW SIN(ALPHAB)-HW*COS( ALPHAB)))      (N 160)
ETA=ETA1-YSTAR*SIGMAW      (N 161)
XOVERH=SIGMAR*GAMMA*((TL-LW)*COS( ALPHAB)+(TH-HW)*SIN( ALPHAB)-      (N 162)
1      ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*COS( ALPHAB))      (N 163)
YOVERH=GAMMA*(0.25*(5.0-2.)*FLOAT(M1))*SIGMAT-YSTAR*SIGMAW      (N 164)
ZOVERH=-SIGMAR*GAMMA*((TL-LW)*SIN( ALPHAB)+(TH-HW)*COS( ALPHAB)-      (N 165)
1      ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*SIN( ALPHAB))      (N 166)
630 CALL DLTAS (C(K))      (N 167)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
      DO 805 L1=1,28      (N 168)
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)      (N 169)
802 CONTINUE      (N 170)
801 CONTINUE      (N 171)
      DO 807 L3=1,28      (N 172)
807 DELTA(L3)=XDELTA(L3)*SUML      (N 173)
      WRITE (6,149) C(K)      (N 174)
      WRITE (6,150) (DELTA(I),I=1,25,4)      (N 175)
      WRITE (6,151) (DELTA(I),I=2,26,4)      (N 176)
      WRITE (6,152) (DELTA(I),I=3,27,4)      (N 177)
      WRITE (6,153) (DELTA(I),I=4,28,4)      (N 178)
      DO 814 L4=1,28      (N 179)
814 XDELTA(L4)=0.      (N 180)
      41 CONTINUE      (N 181)
      42 CONTINUE      (N 182)
      GO TO 1      (N 183)
100 FORMAT (1H1//////////59X*START NEW CASE*)      (N 184)
149 FORMAT (1X*CHI =* F7.3/)      (N 185)
150 FORMAT (3X5H(W,L)7(F17.4))      (N 186)
151 FORMAT (3X5H(U,L)7(F17.4))      (N 187)
152 FORMAT (3X5H(W,D)7(F17.4))      (N 188)
153 FORMAT (3X5H(U,D)7(F17.4)///)      (N 189)
210 FORMAT (1X131(1H-))      (N 190)
211 FORMAT (1X1H11X1H131X61HCORRECTION FACTORS FOR CORRECTING FROM A      (N 191)
1WIND TUNNEL WHICH IS25X1HI)      (N 192)
212 FORMAT (1X1H11X1H1117(1H-)1HI)      (N 193)
213 FORMAT (1X1H111X1H116X1H15X6HCLOSED5X1H116X1H12X12HCLOSED FLOOR2X1      (N 194)
1H16X4HOPEN6X1H116X1H15X6HCLOSED4X1H1)      (N 195)
214 FORMAT (1X1H13X5HDELTA3X1H15X6HCLOSED5X1H14X9HON BOTTOM3X1H16X4HOP      (N 196)
1EN6X1H16X4HONLY6X1H15X5HFLDOR6X1H15X6HCLOSED5X1H13X9HON BOTTOM3X1H      (N 197)
21)      (N 198)
215 FORMAT (1X1H11X1H116X1H16X4HONLY6X1H116X18H1(GROUND EFFECT) 16X4H      (N 199)
1ONLY6X1H116X1H16X4HONLY5X1H1)      (N 200)
216 FORMAT (1X1H11X1H184(1H-)1H132(1H-)1HI)      (N 201)
217 FORMAT (1X1H11X1H136X11H1TO FREE AIR37X1H18X16H1TO GROUND EFFECT8X1      (N 202)
1HI)      (N 203)
218 FORMAT (1X131(1H-))      (N 204)
701 FORMAT (1H1//35X*AVERAGE INTERFERENCE OVER A TAIL BEHIND AN UNLOAD      (N 205)
1ED ROTOR MODEL*///)      (N 206)
702 FORMAT (55X*EFFECT OF ROTOR ON TAIL*///)      (N 207)
703 FORMAT (55X*EFFECT OF WING ON TAIL*///)      (N 208)
706 FORMAT (34X,410* ROTOR LOADING*19X,A8* WING LOADING*//      (N 209)
119X*SIGMA(ROTOR) =*F6.3,10X*ZETA =*F6.3,10X*LW/R =*F6.3,10X      (N 210)
2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING) =*F6.3,10X*ETA =*F6.3,      (N 211)
310X*HW/R =*F6.3,10X*ALPHA(BODY) =*F7.3//19X*SIGMA(TAIL) =*      (N 212)
4F6.3,21X*TL/R =*F6.3,30X*TH/R =*F6.3//39X*GAMMA =*F6.3,27X      (N 213)
5*LAMBDA =*F7.3//)      (N 214)
707 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE      (N 215)
1 FOR USE WITH SUCH CASES.*//)      (N 216)
900 FORMAT (11,F9.3,4F10.3/11,F9.3,4F10.3/3F10.3)      (N 217)
999 STOP      (N 218)
      END      (N 219)

```

## APPENDIX Q

### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER SIDE-BY-SIDE ROTOR CONFIGURATIONS

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 5000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE OLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (THREE CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN AT THE POINT MIDWAY BETWEEN THE TWO ROTORS. THE REQUIRED INPUT VARIABLES FOR THE ROTORS, GIVEN ON THE FIRST CARD, ARE

LIR	ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
SR	DISTANCE BETWEEN ROTOR CENTERS DIVIDED BY ROTOR DIAMETER
ALPHAR	ANGLE OF ATTACK OF TIP-PATH PLANE OF ROTORS, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE

LIW	WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW	DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW	DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH
LAMBDA	WING SWEEP ANGLE, DEG

## Appendix O – Continued

ALPHAB      ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS. THIS PROGRAM ALSO DETERMINES AND REJECTS CASES IN WHICH TOTAL ROTOR SPAN EXCEEDS THE TUNNEL WIDTH.

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT EACH OF THE THREE ELEMENTS DUE TO ITS OWN PRESENCE, AS WELL AS THE INTERFERENCE ON EACH DUE TO THE PRESENCE OF THE OTHER TWO ELEMENTS. IN SYMMETRICAL CASES, THE EFFECTS ON, AND CAUSED BY, EACH OF THE ROTORS IS IDENTICAL. CONSEQUENTLY, ONLY THE INTERFERENCES RELATED TO ONE OF THE ROTORS IS CALCULATED.

NOTE THAT THIS PROGRAM IS ALSO SUITABLE FOR TWIN-PROPELLER TILT-WING MODELS, TILT-ROTOR MODELS, FAN-IN-WING MODELS, AND OTHER SIMILAR TYPES. JUDICIOUS CHOICE OF INPUT VARIABLES WILL SATISFY THE REQUIREMENTS OF THESE, AND MANY OTHER MODELS.

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PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)           (O 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)             (O 2)
DIMENSION XDELTA(28),PSI(20),RLQAD(20),RUNIF(20),RTRIA(20),      (O 3)
1      XLE(10),XLOAD(20),C(8)                                     (O 4)
REAL LAMBDA,LW                                                     (O 5)
DATA (RUNIF(I),I=1,20)/4*.2981,8*.6255,8*.8921/                 (O 6)
DATA (RTRIA(I),I=1,20)/4*.4386,8*.7296,8*.9262/                 (O 7)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./             (O 8)
PI=3.14159265358979                                              (O 9)
RAD=0.0174532925199                                             (O 10)
DO 803 L1=L,28                                                    (O 11)
803 XDELTA(L1)=0.                                                (O 12)
PSI(1)=(PI/4.)                                                    (O 13)
PSI(2)=3.*PSI(1)                                                  (O 14)
PSI(3)=5.*PSI(1)                                                  (O 15)
PSI(4)=7.*PSI(1)                                                  (O 16)
PSI(5)=PSI(13)=(PI/8.)                                           (O 17)
PSI(6)=PSI(14)=3.*PSI(5)                                         (O 18)
PSI(7)=PSI(15)=5.*PSI(5)                                         (O 19)
PSI(8)=PSI(16)=7.*PSI(5)                                         (O 20)
PSI(9)=PSI(17)=9.*PSI(5)                                         (O 21)
PSI(10)=PSI(18)=11.*PSI(5)                                       (O 22)
PSI(11)=PSI(19)=13.*PSI(5)                                       (O 23)
PSI(12)=PSI(20)=15.*PSI(5)                                       (O 24)
XLE(1)=XLE(10)=0.43579                                           (O 25)
XLE(2)=XLE(9) =0.71422                                           (O 26)
XLE(3)=XLE(8) =0.86603                                           (O 27)
XLE(4)=XLE(7) =0.95394                                           (O 28)
XLE(5)=XLE(6) =0.99499                                           (O 29)
1 READ (5,900) LIR,ZETA1,ETA1,GAMMA,SIGMAR,SR,ALPHAR,LIW,LW,HW, (O 30)
1      SIGMAW,LAMBDA,ALPHAB                                       (O 31)
IF (EOF,5) 999,47                                                (O 32)
47 AALPR=ALPHAR                                                    (O 33)
AALPB=ALPHAB                                                       (O 34)
ALAM=LAMBDA                                                        (O 35)
LAMBDA=LAMBDA*RAD                                                 (O 36)
ALPHAR=ALPHAR*RAD                                                 (O 37)
ALPHAB=ALPHAB*RAD                                                 (O 38)
WRITE (6,100)                                                     (O 39)
IF (LIR.EQ.1) GO TO 804                                          (O 40)

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# Appendix O - Continued

IALPHA=10HTRIANGULAR	(0 41)
DO 808 M2=1,20	(0 42)
808 RLOAD(M2)=RTRIA(M2)	(0 43)
GO TO 806	(0 44)
804 IALPHA=10HUNIFORM	(0 45)
DO 809 M2=1,20	(0 46)
809 RLOAD(M2)=RUNIF(M2)	(0 47)
806 IF (LI4.EQ.1) GO TO 852	(0 48)
IBETA=8HELLIPTIC	(0 49)
DO 851 M3=1,10	(0 50)
851 XLOAD(M3)=XLF(M3)	(0 51)
GO TO 850	(0 52)
852 IBETA=8HUNIFORM	(0 53)
DO 853 M3=1,10	(0 54)
853 XLOAD(M3)=1.0	(0 55)
850 WIDTH=SIGMAR*(1.0+SR)	(0 56)
IF (WIDTH.LT.1.0.AND.SIGMAR.NE.0.) GO TO 855	(0 57)
WRITE (6,701)	(0 58)
WRITE (6,711) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,	(0 59)
1 HW,AALPB,GAMMA,SR,ALAM	(0 60)
WRITE (6,210)	(0 61)
WRITE (6,211)	(0 62)
WRITE (6,212)	(0 63)
WRITE (6,213)	(0 64)
WRITE (6,214)	(0 65)
WRITE (6,215)	(0 66)
WRITE (6,216)	(0 67)
WRITE (6,217)	(0 68)
WRITE (6,218)	(0 69)
IF (SIGMAR.EQ.0.) WRITE (6,712)	(0 70)
IF (WIDTH.GE.1.) WRITE (6,717)	(0 71)
GO TO 1	(0 72)
855 DO 42 IELEM=1,9	(0 73)
IF (ETA1.EQ.1.) GO TO (600,600,600,42,42,42,600,600,42), IELEM	(0 74)
600 WRITE (6,701)	(0 75)
IF (ETA1.EQ.1.) GO TO (501,502,503,42,42,42,607,504,42), IELEM	(0 76)
GO TO (601,602,603,604,605,606,607,608,609), IELEM	(0 77)
601 WRITE (6,702)	(0 78)
GO TO 610	(0 79)
602 WRITE (6,703)	(0 80)
GO TO 610	(0 81)
603 WRITE (6,704)	(0 82)
GO TO 610	(0 83)
604 WRITE (6,705)	(0 84)
GO TO 610	(0 85)
605 WRITE (6,706)	(0 86)
GO TO 610	(0 87)
606 WRITE (6,707)	(0 88)
GO TO 610	(0 89)
607 WRITE (6,708)	(0 90)
GO TO 610	(0 91)
608 WRITE (6,709)	(0 92)
GO TO 610	(0 93)
609 WRITE (6,710)	(0 94)
GO TO 610	(0 95)
501 WRITE (6,713)	(0 96)
GO TO 610	(0 97)
502 WRITE (6,714)	(0 98)
GO TO 610	(0 99)
503 WRITE (6,715)	(0 100)
GO TO 610	(0 101)

# Appendix O – Continued

504	WRITE (6,710)	(0 102)
610	WRITE (6,711) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,	(0 103)
1	HW,AALPB,GAMMA,SR,ALAM	(0 104)
	WRITE (6,210)	(0 105)
	WRITE (6,211)	(0 106)
	WRITE (6,212)	(0 107)
	WRITE (6,213)	(0 108)
	WRITE (6,214)	(0 109)
	WRITE (6,215)	(0 110)
	WRITE (6,216)	(0 111)
	WRITE (6,217)	(0 112)
	WRITE (6,218)	(0 113)
	DO 41 K=1,3	(0 114)
	M7=N7=20	(0 115)
	GO TO (611,611,612,611,611,612,613,614,614), IELEM	(0 116)
C		(0 117)
C	ROTOR ON ROTOR	(0 118)
C		(0 119)
611	SUML=0.0025	(0 120)
	GO TO 812	(0 121)
C		(0 122)
C	WING ON ROTOR	(0 123)
C		(0 124)
612	SUML=0.0063052	(0 125)
	IF (SIGMAW.EQ.0.) GO TO 615	(0 126)
	IF (LIW.EQ.1) SUML=0.005	(0 127)
	N7=10	(0 128)
	GO TO 812	(0 129)
615	SUML=0.05	(0 130)
	XLOAD(1)=1.0	(0 131)
	N7=1	(0 132)
	GO TO 812	(0 133)
C		(0 134)
C	WING ON WING	(0 135)
C		(0 136)
613	SUML=0.0126104	(0 137)
	IF (SIGMAW.EQ.0.) GO TO 616	(0 138)
	IF (LIW.EQ.1) SUML=0.010	(0 139)
	M7=10	(0 140)
	N7=10	(0 141)
	IF (ETA1.NE.1.) GO TO 812	(0 142)
	SUML=0.0252208	(0 143)
	IF (LIW.EQ.1) SUML=0.020	(0 144)
	N7=5	(0 145)
	GO TO 812	(0 146)
616	SUML=1.	(0 147)
	XLOAD(1)=1.0	(0 148)
	M7=N7=1	(0 149)
	GO TO 812	(0 150)
C		(0 151)
C	ROTOR ON WING	(0 152)
C		(0 153)
614	SUML=0.0050	(0 154)
	M7=10	(0 155)
	IF (SIGMAW.NE.0.) GO TO 812	(0 156)
	M7=1	(0 157)
	SUML=0.05	(0 158)
812	DO 801 M1=1,M7	(0 159)
	DO 802 N1=1,N7	(0 160)
	XSTAR=(11.-2.*FLOAT(M1))/10.	(0 161)
	YSTAR=(11.-2.*FLOAT(N1))/10.	(0 162)

# Appendix O - Continued

811	GO TO (621,622,623,624,625,626,627,628,629), IELEM	(0 163)
C		(0 164)
C	RIGHT ROTOR ON RIGHT ROTOR	(0 165)
C		(0 166)
621	ETA=ETA1-RLDAD(N1)*SIGMAR*SIN(PSI(N1))-SR*SIGMAR	(0 167)
	YOVERH=SIGMAR*GAMMA*(RLDAD(M1)*SIN(PSI(M1))-RLDAD(N1)*SIN(PSI	(0 168)
1	(N1)))	(0 169)
	GO TO 631	(0 170)
C		(0 171)
C	LEFT ROTOR ON RIGHT ROTOR	(0 172)
C		(0 173)
622	ETA=ETA1-RLDAD(N1)*SIGMAR*SIN(PSI(N1))+SR*SIGMAR	(0 174)
	YOVERH=SIGMAR*GAMMA*(RLDAD(M1)*SIN(PSI(M1))-RLDAD(N1)*SIN(PSI	(0 175)
1	(N1))+2.0*SR)	(0 176)
	GO TO 631	(0 177)
C		(0 178)
C	LEFT ROTOR ON LEFT ROTOR	(0 179)
C		(0 180)
624	ETA=ETA1-RLDAD(N1)*SIGMAR*SIN(PSI(N1))+SR*SIGMAR	(0 181)
	YOVERH=SIGMAR*GAMMA*(RLDAD(M1)*SIN(PSI(M1))-RLDAD(N1)*SIN(PSI	(0 182)
1	(N1)))	(0 183)
	GO TO 631	(0 184)
C		(0 185)
C	RIGHT ROTOR ON LEFT ROTOR	(0 186)
C		(0 187)
625	ETA=ETA1-RLDAD(N1)*SIGMAR*SIN(PSI(N1))-SR*SIGMAR	(0 188)
	YOVERH=SIGMAR*GAMMA*(RLDAD(M1)*SIN(PSI(M1))-RLDAD(N1)*SIN(PSI	(0 189)
1	(N1))-2.0*SR)	(0 190)
631	ZETA=ZETA1/(1.0-RLDAD(N1)*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))*	(0 191)
1	SIN(ALPHAB))	(0 192)
	XOVERH=SIGMAR*GAMMA*COS(ALPHAB)*(RLDAD(M1)*COS(PSI(M1))-	(0 193)
1	RLDAD(N1)*COS(PSI(N1)))	(0 194)
	ZOVERH=-SIGMAR*GAMMA*SIN(ALPHAB)*(RLDAD(M1)*COS(PSI(M1))-	(0 195)
1	RLDAD(N1)*COS(PSI(N1)))	(0 196)
	XLOAD(N1)=1.0	(0 197)
	GO TO 640	(0 198)
C		(0 199)
C	WING ON RIGHT ROTOR	(0 200)
C		(0 201)
623	YOVERH=SIGMAR*GAMMA*(RLDAD(M1)*SIN(PSI(M1))+SR-YSTAR*	(0 202)
1	(SIGMAW/SIGMAR))	(0 203)
	GO TO 632	(0 204)
C		(0 205)
C	WING ON LEFT ROTOR	(0 206)
C		(0 207)
626	YOVERH=SIGMAR*GAMMA*(RLDAD(M1)*SIN(PSI(M1))-SR-YSTAR*	(0 208)
1	(SIGMAW/SIGMAR))	(0 209)
632	ETA=ETA1-YSTAR*SIGMAW	(0 210)
	ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR)*	(0 211)
1	TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)))	(0 212)
	ZOVERH=-SIGMAR*GAMMA*(RLDAD(M1)*SIN(ALPHAB)*COS(PSI(M1))-	(0 213)
1	ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*SIN(ALPHAB)-	(0 214)
2	LW*SIN(ALPHAB)+HW*COS(ALPHAB))	(0 215)
	XOVERH=SIGMAR*GAMMA*(RLDAD(M1)*COS(ALPHAB)*COS(PSI(M1))-	(0 216)
1	ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*COS(ALPHAB)-	(0 217)
2	LW*COS(ALPHAB)-HW*SIN(ALPHAB))	(0 218)
	GO TO 640	(0 219)
C		(0 220)
C	WING ON WING	(0 221)
C		(0 222)
627	ETA=ETA1-YSTAR*SIGMAW	(0 223)

# Appendix O - Continued

```

      ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(YSTAR*(SIGMAW/SIGMAR)*
1      TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)))
      XOVERH=SIGMAW*GAMMA*TAN(LAMBDA)*COS(ALPHAB)*(ABS(XSTAR)-
1      ABS(YSTAR))
      YOVERH=C.2*SIGMAW*GAMMA*(FLOAT(N1)-FLOAT(M1))
      ZOVERH=-SIGMAW*GAMMA*TAN(LAMBDA)*SIN(ALPHAB)*(ABS(XSTAR)-
1      ABS(YSTAR))
      GO TO 640
C
C      RIGHT ROTOR ON WING
C
628 ETA=ETA1-RLOAD*SIGMAR*SIN(PSI(N1))-SR*SIGMAR
      YOVERH=SIGMAR*GAMMA*(XSTAR*(SIGMAW/SIGMAR)-RLOAD(N1)*SIN(PSI
1      (N1))-SR)
      GO TO 633
C
C      LEFT ROTOR ON WING
C
629 ETA=ETA1-RLOAD*SIGMAR*SIN(PSI(N1))+SR*SIGMAR
      YOVERH=SIGMAR*GAMMA*(XSTAR*(SIGMAW/SIGMAR)-RLOAD(N1)*SIN(PSI
1      (N1))+SR)
633 ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*RLOAD(N1)*SIN(ALPHAB)*
1      COS(PSI(N1)))
      XOVERH=SIGMAR*GAMMA*(ABS(XSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*
1      COS(ALPHAB)+LW*COS(ALPHAB)+HW*SIN(ALPHAB)-RLOAD(N1)*
2      COS(ALPHAB)*COS(PSI(N1)))
      ZOVERH=-SIGMAR*GAMMA*(ABS(XSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*
1      SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB)-RLOAD(N1)*
2      SIN(ALPHAB)*COS(PSI(N1)))
      XLOAD(N1)=1.0
640 CALL DLTAS (C(K))
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
      DO 805 L1=1,28
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1)
802 CONTINUE
801 CONTINUE
      DO 807 L3=1,28
807 DELTA(L3)=XDELTA(L3)*SUML
      WRITE (6,149) C(K)
      WRITE (6,150) (DELTA(I),I=1,25,4)
      WRITE (6,151) (DELTA(I),I=2,26,4)
      WRITE (6,152) (DELTA(I),I=3,27,4)
      WRITE (6,153) (DELTA(I),I=4,28,4)
      DO 814 L4=1,29
814 XDELTA(L4)=0.
      41 CONTINUE
      42 CONTINUE
      GO TO 1
100 FORMAT (1H1/////////59X*START NEW CASE*)
149 FORMAT (1X*CHI =* F7.3/)
150 FORMAT (3X5H(W,L)7(F17.4))
151 FORMAT (3X5H(U,L)7(F17.4))
152 FORMAT (3X5H(W,D)7(F17.4))
153 FORMAT (3X5H(U,D)7(F17.4)///)
210 FORMAT (1X131(1H-))
211 FORMAT (1X1H11X1H131X61HCORRECTION FACTORS FOR CORRECTING FROM A
1WIND TUNNEL WHICH IS25X1H1)
212 FORMAT (1X1H111X1H1117(1H-)1H1)
213 FORMAT (1X1H111X1H116X1H15X6HCLOSED5X1H116X1H12X12HCLOSED FLOOR2X1
1H16X4HOPEN6X1H116X1H15X6HCLOSED4X1H1)
214 FORMAT (1X1H13X5HDELTA3X1H15X6HCLOSED5X1H14X9HON BOTTOM3X1416X4HOP

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# Appendix O - Concluded

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1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X5HCLDSE5X1HI3X9HON BOTTOM3X1H (0 284)
2I) (0 295)
215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 16X4H (0 286)
1ONLY6X1HI16X1HI6X4HONLY5X1HI) (0 287)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (0 288)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTO GROUND EFFECT8X1 (0 289)
1HI) (0 290)
218 FORMAT (1X131(1H-)/) (0 291)
701 FORMAT (1H1//35X* AVERAGE INTERFERENCE OVER SIDE-BY-SIDE AND/OR TIL (0 292)
1T-ROTOR MODELS*/) (0 293)
702 FORMAT (48X*EFFECT OF RIGHT ROTOR ON RIGHT ROTOR*//) (0 294)
703 FORMAT (48X*EFFECT OF LEFT ROTOR ON RIGHT ROTOR*//) (0 295)
704 FORMAT (51X*EFFECT OF WING ON RIGHT ROTOR*//) (0 296)
705 FORMAT (49X*EFFECT OF LEFT ROTOR ON LEFT ROTOR*//) (0 297)
706 FORMAT (48X*EFFECT OF RIGHT ROTOR ON LEFT ROTOR*//) (0 298)
707 FORMAT (52X*EFFECT OF WING ON LEFT ROTOR*//) (0 299)
708 FORMAT (55X*EFFECT OF WING ON WING*//) (0 300)
709 FORMAT (51X*EFFECT OF RIGHT ROTOR ON WING*//) (0 301)
710 FORMAT (52X*EFFECT OF LEFT ROTOR ON WING*//) (0 302)
711 FORMAT (34X, A10* ROTOR LOADING*19X, A8* WING LOADING*// (0 303)
119X*SIGMA(ROTOR) =*F6.3, 10X*ZETA =*F6.3, 10X*W/R =*F6.3, 10X (0 304)
2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING) =*F6.3, 10X*ETA =*F6.3, (0 305)
310X*W/R =*F6.3, 10X*ALPHA(BODY) =*F7.3//19X*GAMMA =*F6.3, (0 306)
428X*SR/R =*F6.3, 27X*LAMBDA =*F7.3//) (0 307)
712 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE (0 308)
1 FOR USE WITH SUCH CASES.*//) (0 309)
713 FORMAT (50X*EFFECT OF EITHER ROTOR ON ITSELF*//) (0 310)
714 FORMAT (47X*EFFECT OF OTHER ROTOR ON EITHER ROTOR*//) (0 311)
715 FORMAT (51X*EFFECT OF WING ON EITHER ROTOR*//) (0 312)
716 FORMAT (51X*EFFECT OF EITHER ROTOR ON WING*//) (0 313)
717 FORMAT (40X*ROTOR SYSTEM IS TOO WIDE FOR THE WIND TUNNEL*//) (0 314)
900 FORMAT (11, F9.3, 5F10.3/11, F9.3, 4F10.3) (0 315)
999 STOP (0 316)
END (0 317)

```

## APPENDIX P

### FORTRAN PROGRAM FOR CALCULATING THE AVERAGE WIND-TUNNEL INTERFERENCE OVER A TAIL BEHIND A SIDE-BY-SIDE ROTOR CONFIGURATION

THIS PROGRAM WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS PROGRAM HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS PROGRAM REQUIRES THE USE OF SUBROUTINE DLTAS WHICH IS GIVEN IN APPENDIX Q.

INPUT WILL BE FOUND AT ADDRESS 1 (THREE CARDS PER CASE) IN FORMAT 900. NOTE THAT THE REFERENCE ORIGIN IS CHOSEN AT THE POINT MIDWAY BETWEEN THE TWO ROTORS. THE REQUIRED INPUT VARIABLES FOR THE ROTORS, GIVEN ON THE FIRST CARD, ARE

LIR	ROTOR DISK-LOAD-DISTRIBUTION INDICATOR, LIR=1 FOR UNIFORM LOADING, LIR=2 FOR TRIANGULAR LOADING
ZETA1	SEMIHEIGHT OF TUNNEL DIVIDED BY HEIGHT OF ORIGIN ABOVE FLOOR
ETA1	DISTANCE FROM ORIGIN TO RIGHT-HAND WALL DIVIDED BY TUNNEL SEMIWIDTH
GAMMA	WIDTH-HEIGHT RATIO OF WIND TUNNEL
SIGMAR	RATIO OF ROTOR DIAMETER TO TUNNEL WIDTH
SR	DISTANCE BETWEEN ROTOR CENTERS DIVIDED BY ROTOR DIAMETER
ALPHAR	ANGLE OF ATTACK OF TIP-PATH PLANE OF ROTORS, DEG

THE REQUIRED INPUT VARIABLES FOR THE WING, GIVEN ON THE SECOND CARD, ARE

LIW	WING SPAN-LOAD-DISTRIBUTION INDICATOR, LIW=1 FOR UNIFORM LOADING, LIW=2 FOR ELLIPTIC LOADING
LW	DISTANCE OF WING APEX BEHIND ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
HW	DISTANCE OF WING APEX ABOVE ORIGIN, NONDIMENSIONALIZED WITH RESPECT TO ROTOR RADIUS
SIGMAW	RATIO OF WING SPAN TO TUNNEL WIDTH

## Appendix P – Continued

LAMBDA     WING SWEEP ANGLE, DEG

ALPHAB     ANGLE OF ATTACK OF BODY CARRYING WING AND TAIL, DEG

THE REQUIRED INPUT VARIABLES FOR THE TAIL, ON THE THIRD CARD, ARE

SIGMAT     RATIO OF TAIL SPAN TO TUNNEL WIDTH

TL           TAIL LENGTH BEHIND ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSION-  
ALIZED WITH RESPECT TO ROTOR RADIUS

TH           TAIL HEIGHT ABOVE ORIGIN AT ZERO ANGLE OF ATTACK, NONDIMENSION-  
ALIZED WITH RESPECT TO ROTOR RADIUS

THIS PROGRAM COMPUTES INDEPENDENTLY THE INTERFERENCE AT THE TAIL CAUSED BY THE PRESENCE OF THE THREE LIFTING ELEMENTS. IN SYMMETRICAL CASES, THE EFFECT OF THE TWO ROTORS IS IDENTICAL. CONSEQUENTLY, ONLY THE INTERFERENCE CAUSED BY ONE ROTOR IS CALCULATED.

THIS PROGRAM REJECTS CASES OF ZERO SPAN. SINCE THE EQUATIONS ARE FORMED IN TERMS OF ROTOR RADIUS, SUCH CASES REPRESENT INPUT ERRORS. THIS PROGRAM ALSO DETERMINES AND REJECTS CASES IN WHICH TOTAL ROTOR SPAN EXCEEDS THE TUNNEL WIDTH.

NOTE THAT THIS PROGRAM IS ALSO SUITABLE FOR TWIN-PROPELLER TILT-WING MODELS, TILT-ROTOR MODELS, FAN-IN-WING MODELS, AND OTHER SIMILAR TYPES. JUDICIOUS CHOICE OF INPUT VARIABLES WILL SATISFY THE REQUIREMENTS OF THESE, AND MANY OTHER MODELS.

```

PROGRAM WINDTUN(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)          (P 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)             (P 2)
DIMENSION XDELTA(28),PSI(20),RLOAD(20),RUNIF(20),RTRIA(20),      (P 3)
1      XLE(10),XLOAD(20),C(8)                                     (P 4)
REAL LAMBDA,LW                                                    (P 5)
DATA (RUNIF(I),I=1,20)/4*0.2981,8*0.6255,8*0.8921/              (P 6)
DATA (RTRIA(I),I=1,20)/4*0.4386,8*0.7296,8*0.9262/              (P 7)
DATA (C(I),I=1,8)/20.,30.,40.,50.,60.,70.,80.,90./              (P 8)
PI=3.14159265358979                                              (P 9)
RAD=0.0174532925199                                              (P 10)
DO 803 L1=1,28                                                    (P 11)
803 XDELTA(L1)=0.                                                 (P 12)
PSI(1)=(PI/4.)                                                    (P 13)
PSI(2)=3.*PSI(1)                                                  (P 14)
PSI(3)=5.*PSI(1)                                                  (P 15)
PSI(4)=7.*PSI(1)                                                  (P 16)
PSI(5)=PSI(13)=(PI/8.)                                            (P 17)
PSI(6)=PSI(14)=3.*PSI(5)                                          (P 18)
PSI(7)=PSI(15)=5.*PSI(5)                                          (P 19)
PSI(8)=PSI(16)=7.*PSI(5)                                          (P 20)
PSI(9)=PSI(17)=9.*PSI(5)                                          (P 21)
PSI(10)=PSI(18)=11.*PSI(5)                                        (P 22)
PSI(11)=PSI(19)=13.*PSI(5)                                        (P 23)
PSI(12)=PSI(20)=15.*PSI(5)                                        (P 24)
XLE(1)=XLE(10)=0.43579                                            (P 25)
XLE(2)=XLE(9) =0.71422                                            (P 26)
XLE(3)=XLE(8) =0.86603                                            (P 27)

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# Appendix P - Continued

XLE(4)=XLE(7) =C.95394	(P 28)
XLE(5)=XLE(6) =0.99499	(P 29)
1 READ (5,900) LIR,ZETA1,ETA1,GAMMA,SIGMAR,SR,ALPHAR,LIW,LW,HW,	(P 30)
1 SIGMAW,LAMBDA,ALPHAB,SIGMAT,TL,TH	(P 31)
IF (EOF,5) 999,47	(P 32)
47 AALPR=ALPHAR	(P 33)
AALPB=ALPHAB	(P 34)
ALAM=LAMBDA	(P 35)
LAMBDA=LAMBDA*RAD	(P 36)
ALPHAR=ALPHAR*RAD	(P 37)
ALPHAB=ALPHAB*RAD	(P 38)
WRITE (6,100)	(P 39)
IF (LIR.EQ.1) GO TO 804	(P 40)
IALPHA=10*TRIANGULAR	(P 41)
DO 808 M2=1,20	(P 42)
808 RLOAD(M2)=RTRIA(M2)	(P 43)
GO TO 806	(P 44)
804 IALPHA=10HUNIFORM	(P 45)
DO 809 M2=1,20	(P 46)
809 RLOAD(M2)=RUNIF(M2)	(P 47)
806 IF (LIW.EQ.1) GO TO 852	(P 48)
IBETA=8*ELLIPTIC	(P 49)
DO 851 M3=1,10	(P 50)
851 XLOAD(M3)=XLE(M3)	(P 51)
GO TO 850	(P 52)
852 IBETA=8HUNIFORM	(P 53)
DO 853 M3=1,10	(P 54)
853 XLOAD(M3)=1.0	(P 55)
850 WIDTH=SIGMAR*(1.0+SR)	(P 56)
IF (WIDTH.LT.1..AND.SIGMAR.NE.0.) GO TO 855	(P 57)
WRITE (6,701)	(P 58)
WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,	(P 59)
1 HW,AALPB,SIGMAT,TL,TH,SR,GAMMA,ALAM	(P 60)
WRITE (6,210)	(P 61)
WRITE (6,211)	(P 62)
WRITE (6,212)	(P 63)
WRITE (6,213)	(P 64)
WRITE (6,214)	(P 65)
WRITE (6,215)	(P 66)
WRITE (6,216)	(P 67)
WRITE (6,217)	(P 68)
WRITE (6,218)	(P 69)
IF (SIGMAR.EQ.0.) WRITE (6,707)	(P 70)
IF (WIDTH.GE.1.) WRITE (6,708)	(P 71)
GO TO 1	(P 72)
855 CO 42 IELEM=1,3	(P 73)
IF (ETA1.EQ.1.) GO TO (600,42,600), IELEM	(P 74)
600 WRITE (6,701)	(P 75)
IF (ETA1.EQ.1.) GO TO (604,42,603), IELEM	(P 76)
GO TO (601,602,603), IELEM	(P 77)
601 WRITE (6,702)	(P 78)
GO TO 610	(P 79)
602 WRITE (6,703)	(P 80)
GO TO 610	(P 81)
603 WRITE (6,704)	(P 82)
GO TO 610	(P 83)
604 WRITE (6,705)	(P 84)
610 WRITE (6,706) IALPHA,IBETA,SIGMAR,ZETA1,LW,AALPR,SIGMAW,ETA1,	(P 85)
1 HW,AALPB,SIGMAT,TL,TH,SR,GAMMA,ALAM	(P 86)
WRITE (6,210)	(P 87)
WRITE (6,211)	(P 88)

# Appendix P - Continued

WRITE (6,212)	(P 89)
WRITE (6,213)	(P 90)
WRITE (6,214)	(P 91)
WRITE (6,215)	(P 92)
WRITE (6,216)	(P 93)
WRITE (6,217)	(P 94)
WRITE (6,218)	(P 95)
DO 41 K=1,8	(P 96)
N7=20	(P 97)
M7=4	(P 98)
GO TO (611,611,612), IELEM	(P 99)
C	(P 100)
C EFFECT OF ROTOR	(P 101)
C	(P 102)
611 SUML=0.0125	(P 103)
GO TO 812	(P 104)
C	(P 105)
C EFFECT OF WING	(P 106)
C	(P 107)
612 SUML=0.031526	(P 108)
IF (SIGMAW.EQ.0..OR.SIGMAT.EQ.0.) GO TO 615	(P 109)
IF (LIW.EQ.1) SUML=0.025	(P 110)
N7=10	(P 111)
IF (ETA1.NE.1.) GO TO 812	(P 112)
SUML=0.0126104	(P 113)
IF (LIW.EQ.1) SUML=0.050	(P 114)
N7=5	(P 115)
GO TO 812	(P 116)
615 IF (SIGMAW.EQ.0..AND.SIGMAT.NE.0.) GO TO 613	(P 117)
IF (SIGMAW.NE.0..AND.SIGMAT.EQ.0.) GO TO 616	(P 118)
SUML=1.0	(P 119)
XLOAD(1)=1.0	(P 120)
M7=N7=1	(P 121)
GO TO 812	(P 122)
613 SUML=0.25	(P 123)
M7=4	(P 124)
N7=1	(P 125)
XLOAD(1)=1.0	(P 126)
IF (ETA1.NE.1.) GO TO 812	(P 127)
SUML=0.50	(P 128)
M7=2	(P 129)
GO TO 812	(P 130)
616 SUML=0.126104	(P 131)
IF (LIW.EQ.1) SUML=0.100	(P 132)
N7=10	(P 133)
M7=1	(P 134)
IF (ETA1.NE.1.) GO TO 812	(P 135)
SUML=0.25208	(P 136)
IF (LIW.EQ.1) SUML=0.200	(P 137)
N7=5	(P 138)
812 DO 801 M1=1,M7	(P 139)
DO 802 N1=1,N7	(P 140)
XSTAR=(11.-2.*FLOAT(M1))/10.	(P 141)
YSTAR=(11.-2.*FLOAT(N1))/10.	(P 142)
GO TO (622,623,621), IELEM	(P 143)
C	(P 144)
C EFFECT OF RIGHT ROTOR	(P 145)
C	(P 146)
622 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))-SR*SIGMAR	(P 147)
YOVERH=-SIGMAR*GAMMA*(0.25*(2.0*FLOAT(M1)-5.0)*(SIGMAT/SIGMAR)	(P 148)
1 +RLOAD(N1)*SIN(PSI(N1))+SR)	(P 149)

# Appendix P - Continued

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GO TO 625 (P 150)
C (P 151)
C EFFECT OF LEFT RCTOR (P 152)
C (P 153)
623 ETA=ETA1-RLOAD(N1)*SIGMAR*SIN(PSI(N1))+SR*SIGMAR (P 154)
YOVERH=-SIGMAR*GAMMA*(0.25*(2.0*FLOAT(M1)-5.0)*(SIGMAT/SIGMAR) (P 155)
1 +RLOAD(N1)*SIN(PSI(N1))-SR) (P 156)
GO TO 625 (P 157)
C (P 158)
C EFFECT OF WING (P 159)
C (P 160)
621 YSTAR=(11.0-2.0*FLOAT(N1))/10.0 (P 161)
ETA=ETA1-YSTAR*SIGMAW (P 162)
ZETA=ZETA1/(1.0-SIGMAR*GAMMA*ZETA1*(ABS(YSTAR)*(SIGMAW/SIGMAR) (P 163)
1 *TAN(LAMBDA)*SIN(ALPHAB)+LW*SIN(ALPHAB)-HW*COS(ALPHAB))) (P 164)
XOVERH=SIGMAR*GAMMA*((TL-LW)*COS(ALPHAB)+(TH-HW)*SIN(ALPHAB) (P 165)
1 -ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*COS(ALPHAB)) (P 166)
YOVERH=GAMMA*(0.25*(5.0-2.0*FLOAT(M1))*SIGMAT-YSTAR*SIGMAW) (P 167)
ZOVERH=-SIGMAR*GAMMA*((TL-LW)*SIN(ALPHAB)-(TH-HW)*COS(ALPHAB) (P 168)
1 -ABS(YSTAR)*(SIGMAW/SIGMAR)*TAN(LAMBDA)*SIN(ALPHAB)) (P 169)
GO TO 630 (P 170)
625 ZETA=ZETA1/(1.0-RLOAD(N1)*SIGMAR*GAMMA*ZETA1*COS(PSI(N1))* (P 171)
1 SIN(ALPHAB)) (P 172)
XOVERH=SIGMAR*GAMMA*(TL*COS(ALPHAB)+TH*SIN(ALPHAB)- (P 173)
1 RLOAD(N1)*COS(ALPHAB)*COS(PSI(N1))) (P 174)
ZOVERH=SIGMAR*GAMMA*(TH*COS(ALPHAB)-TL*SIN(ALPHAB)+RLOAD(N1) (P 175)
1 *SIN(ALPHAB)*COS(PSI(N1))) (P 176)
XLOAD(N1)=1.0 (P 177)
630 CALL DLTAS (C(K)) (P 178)
***** SEE APPENDIX Q FOR SUBROUTINE DLTAS *****
DO 805 L1=1,28 (P 179)
805 XDELTA(L1)=XDELTA(L1)+DELTA(L1)*XLOAD(N1) (P 180)
802 CONTINUE (P 181)
801 CONTINUE (P 182)
DO 807 L3=1,28 (P 183)
807 DELTA(L3)=XDELTA(L3)*SUML (P 184)
WRITE (6,149) C(K) (P 185)
WRITE (6,150) (DELTA(I),I=1,25,4) (P 186)
WRITE (6,151) (DELTA(I),I=2,26,4) (P 187)
WRITE (6,152) (DELTA(I),I=3,27,4) (P 188)
WRITE (6,153) (DELTA(I),I=4,28,4) (P 189)
DO 814 L4=1,28 (P 190)
814 XDELTA(L4)=0. (P 191)
41 CONTINUE (P 192)
42 CONTINUE (P 193)
GO TO 1 (P 194)
100 FORMAT (1F1/////////59X*START NEW CASE*) (P 195)
149 FORMAT (1X*CHI =* F7.3/) (P 196)
150 FORMAT (3X5H(W,L)7(F17.4)) (P 197)
151 FORMAT (3X5H(U,L)7(F17.4)) (P 198)
152 FORMAT (3X5H(W,D)7(F17.4)) (P 199)
153 FORMAT (3X5H(U,D)7(F17.4)///) (P 200)
210 FORMAT (1X131(1H-)) (P 201)
211 FORMAT (1X1HI11X1HI31X61HCDRRECTION FACTORS FOR CORRECTING FROM A (P 202)
1WIND TUNNEL WHICH IS25X1HI) (P 203)
212 FORMAT (1X1HI11X1HI117(1H-))1HI) (P 204)
213 FORMAT (1X1HI11X1HI16X1HI5X6HCLOSED5X1HI16X1HI2X12HCLOSED FLOOR2X1 (P 205)
1HI6X4HOPEN6X1HI16X1HI5X6HCLOSED4X1HI) (P 206)
214 FORMAT (1X1HI3X5HDELTA3X1HI5X6HCLOSED5X1HI4X9HON BOTTOM3X1HI6X4HOP (P 207)
1EN6X1HI6X4HONLY6X1HI5X5HFLOOR6X1HI5X6HCLOSED5X1HI3X9HON BOTTOM3X1H (P 208)
2I) (P 209)

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# Appendix P – Concluded

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215 FORMAT (1X1HI11X1HI16X1HI6X4HONLY6X1HI16X18HI(GROUND EFFECT) 16X4H (P 210)
      1ONLY6X1HI16X1HI6X4HONLY5X1HI) (P 211)
216 FORMAT (1X1HI11X1HI84(1H-)1HI32(1H-)1HI) (P 212)
217 FORMAT (1X1HI11X1HI36X11HTO FREE AIR37X1HI8X16HTC GROUND EFFECT8X1 (P 213)
      1HI) (P 214)
218 FORMAT (1X131(1H-)/) (P 215)
701 FORMAT (1HI//28X*AVERAGE INTERFERENCE OVER A TAIL BEHIND SIDE-BY-S (P 216)
      1IDE AND/OR TILT ROTOR MODELS*/) (P 217)
702 FORMAT (55X*EFFECT OF RIGHT ROTOR*//) (P 218)
703 FORMAT (56X*EFFECT OF LEFT ROTOR*//) (P 219)
704 FORMAT (59X*EFFECT OF WING*//) (P 220)
705 FORMAT (55X*EFFECT OF EITHER ROTOR*//) (P 221)
706 FORMAT (34X,410* ROTOR LOADING*19X,48* WING LOADING*// (P 222)
      119X*SIGMA(ROTOR) =*F6.3,10X*ZETA =*F6.3,10X*LW/R =*F6.3,10X (P 223)
      2*ALPHA(ROTOR) =*F7.3//19X*SIGMA(WING) =*F6.3,10X*ETA =*F6.3, (P 224)
      310X*HW/R =*F6.3,10X*ALPHA(BODY) =*F7.3//19X*SIGMA(TAIL) =*F6.3, (P 225)
      410X*TL/R =*F6.3,10X*TH/R =*F6.3,10X*SR/R =*F7.3//39X (P 226)
      5*GAMMA =*F6.3,29X*LAMBDA =*F7.3//) (P 227)
707 FORMAT (40X*SIGMA(ROTOR) EQUALS ZERO, THIS PROGRAM IS NOT SUITABLE (P 228)
      1 FOR USE WITH SUCH CASES.*//) (P 229)
708 FORMAT (40X*ROTOR SYSTEM IS TOO WIDE FOR WIND TUNNEL*//) (P 230)
900 FORMAT (11,F9.3,5F10.3/11,F9.3,4F10.3/3F10.3) (P 231)
999 STOP (P 232)
      END (P 233)

```

# APPENDIX Q

## SUBROUTINE DLTAS

THIS SUBROUTINE WAS WRITTEN IN CDC FORTRAN, VERSION 2.1, TO RUN ON CDC 6000 SERIES COMPUTERS WITH THE SCOPE 3.0 OPERATING SYSTEM AND LIBRARY TAPE. MINOR MODIFICATIONS MAY BE REQUIRED PRIOR TO USE IN OTHER COMPUTERS. THIS SUBROUTINE HAS BEEN FOUND TO BE SATISFACTORY ON THE AFOREMENTIONED COMPUTERS WHICH CARRY THE EQUIVALENT OF APPROXIMATELY 15 DECIMAL DIGITS. COMPUTERS OF LESSER PRECISION MAY REQUIRE MODIFICATION TO DOUBLE PRECISION IN ORDER TO OBTAIN RESULTS OF EQUAL ACCURACY.

THIS SUBROUTINE IS REQUIRED BY THE PROGRAMS OF ALL PRECEEDING APPENDICES.

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SUBROUTINE DLTAS (ANGL)                                (Q 1)
COMMON ZETA,ETA,GAMMA,XOVERH,YOVERH,ZOVERH,DELTA(28)  (Q 2)
DIMENSION V(3,9),ADEL(28)                             (Q 3)
SC=SIN(ANGL*0.0174532925199)                          (Q 4)
CC=COS(ANGL*0.0174532925199)                          (Q 5)
Z6=ZETA*ZOVERH+1.                                       (Q 6)
Z8=-Z6                                                  (Q 7)
Z7=Z8-1.                                                (Q 8)
DO 8 J1=1,28                                           (Q 9)
8 DELTA(J1)=C.                                          (Q 10)
DO 10 M=1,7                                           (Q 11)
DO 10 N=1,7                                           (Q 12)
IF (N.EQ.4.AND.M.EQ.4) GO TO 10                      (Q 13)
DO 11 J1=1,3                                           (Q 14)
DO 11 J2=1,9                                           (Q 15)
11 V(J1,J2)=0.                                         (Q 16)
DO 12 J1=1,28                                          (Q 17)
12 ADEL(J1)=0.                                         (Q 18)
AM=M-4                                                (Q 19)
AN=N-4                                                (Q 20)
X=ZETA*XOVERH                                         (Q 21)
Y=ZETA*(YOVERH-2.*AM*GAMMA+GAMMA*(1.-ETA)*(1.-(-1.)**M)) (Q 22)
Z=ZETA*(ZOVERH-4.*AN)                                (Q 23)
A=SQRT(X*X+Y*Y+Z*Z)                                  (Q 24)
B=A+Z*CC-X*SC                                         (Q 25)
V(1,1)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2    (Q 26)
V(2,1)=-((X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)) (Q 27)
V(3,1)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2    (Q 28)
Z=-Z-2.                                               (Q 29)
A=SQRT(X*X+Y*Y+Z*Z)                                  (Q 30)
B=A+Z*CC-X*SC                                         (Q 31)
V(1,3)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2    (Q 32)
V(2,3)=-((X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)) (Q 33)
V(3,3)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2    (Q 34)
IF (ANGL.EQ.90.0) GO TO 13                          (Q 35)
X=X-(SC/CC)                                           (Q 36)
Z=-Z-1.                                               (Q 37)
A=SQRT(X*X+Y*Y+Z*Z)                                  (Q 38)
B=A+Z*CC-X*SC                                         (Q 39)
V(1,2)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2    (Q 40)
V(2,2)=-((X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A)) (Q 41)

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# Appendix Q – Continued

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V(3,2)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2      (Q 42)
B=A-X                                                         (Q 43)
V(1,5)=((X*X+Y*Y)/(B*A*A*A))-((Z/(B*A))**2               (Q 44)
V(2,5)=Z/(A*A*A)                                             (Q 45)
V(3,5)=X/(A*A*A)                                             (Q 46)
Z=-Z                                                         (Q 47)
B=A+Z*CC-X*SC                                                (Q 48)
V(1,4)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2         (Q 49)
V(2,4)=-((X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A))    (Q 50)
V(3,4)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2         (Q 51)
13 ADEL(1)=V(1,1)-V(1,2)-V(1,3)+V(1,4)                     (Q 52)
   ADEL(2)=V(2,1)-V(2,2)+V(2,3)-V(2,4)                     (Q 53)
   ADEL(3)=V(2,1)-V(2,2)-V(2,3)+V(2,4)+2.*V(2,5)           (Q 54)
   ADEL(4)=V(3,1)-V(3,2)+V(3,3)-V(3,4)+2.*V(3,5)           (Q 55)
   ADEL(5)=((-1.)*M)*ADEL(1)                                 (Q 56)
   ADEL(6)=((-1.)*M)*ADEL(2)                                 (Q 57)
   ADEL(7)=((-1.)*M)*ADEL(3)                                 (Q 58)
   ADEL(8)=((-1.)*M)*ADEL(4)                                 (Q 59)
   ADEL(9)=((-1.)*M)*(V(1,1)-V(1,2)+V(1,3)-V(1,4)+2.*V(1,5)) (Q 60)
   ADEL(10)=((-1.)*M)*(V(2,1)-V(2,2)-V(2,3)+V(2,4)+2.*V(2,5)) (Q 61)
   ADEL(11)=((-1.)*M)*(V(2,1)-V(2,2)+V(2,3)-V(2,4))        (Q 62)
   ADEL(12)=((-1.)*M)*(V(3,1)-V(3,2)-V(3,3)+V(3,4))        (Q 63)
DO 14 J1=1,12                                                (Q 64)
14 DELTA(J1)=DELTA(J1)+ADEL(J1)                               (Q 65)
10 CONTINUE                                                  (Q 66)
DO 15 J1=1,8                                                  (Q 67)
15 DELTA(J1+20)=DELTA(J1)                                     (Q 68)
   X=ZETA*XOVERH                                              (Q 69)
   Y=ZETA*YOVERH                                              (Q 70)
   Z=Z7                                                        (Q 71)
   A=SQRT(X*X+Y*Y+Z*Z)                                         (Q 72)
   B=A+Z*CC-X*SC                                               (Q 73)
   V(1,7)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2         (Q 74)
   V(2,7)=-((X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A))    (Q 75)
   V(3,7)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2         (Q 76)
   IF (ANGL.EQ.90.0) GO TO 16                                  (Q 77)
   X=X-(SC/CC)                                                  (Q 78)
   Z=Z6                                                         (Q 79)
   A=SQRT(X*X+Y*Y+Z*Z)                                         (Q 80)
   B=A+Z*CC-X*SC                                               (Q 81)
   V(1,6)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2         (Q 82)
   V(2,6)=-((X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A))    (Q 83)
   V(3,6)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2         (Q 84)
   B=A-X                                                         (Q 85)
   V(1,9)=((X*X+Y*Y)/(B*A*A*A))-((Z/(B*A))**2               (Q 86)
   V(2,9)=Z/(A*A*A)                                             (Q 87)
   V(3,9)=X/(A*A*A)                                             (Q 88)
   Z=Z8                                                         (Q 89)
   B=A+Z*CC-X*SC                                                (Q 90)
   V(1,8)=((X*X+Y*Y)/(B*A*A*A))-((Z+A*CC)/(B*A))**2         (Q 91)
   V(2,8)=-((X*Z)/(B*A*A*A)-(Z+A*CC)*(X-A*SC)/(B*B*A*A))    (Q 92)
   V(3,8)=((Y*Y+Z*Z)/(B*A*A*A))-((X-A*SC)/(B*A))**2         (Q 93)
16 DELTA(13)=-V(1,6)-V(1,7)+V(1,8)                           (Q 94)
   DELTA(14)=-V(2,6)+V(2,7)-V(2,8)                           (Q 95)
   DELTA(15)=-V(2,6)-V(2,7)+V(2,8)+2.*V(2,9)                 (Q 96)
   DELTA(16)=-V(3,6)+V(3,7)-V(3,8)+2.*V(3,9)                 (Q 97)
   DELTA(17)=-V(1,6)+V(1,7)-V(1,8)+2.*V(1,9)                 (Q 98)
   DELTA(18)=DELTA(15)                                          (Q 99)
   DELTA(19)=DELTA(14)                                          (Q 100)
   DELTA(20)=-V(3,6)-V(3,7)+V(3,8)                             (Q 101)
DO 17 J1=1,4                                                  (Q 102)

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## Appendix Q – Concluded

17 DELTA(J1)=DELTA(J1)+DELTA(J1+12)	(Q 103)
DO 18 J1=5,12	(Q 104)
18 DELTA(J1)=DELTA(J1)+DELTA(J1+8)	(Q 105)
AMT=-2.*GAMMA*ZETA*ZETA/3.14159265358979	(Q 106)
DO 19 J1=1,28	(Q 107)
19 DELTA(J1)=AMT*DELTA(J1)	(Q 108)
RETURN	(Q 109)
END	(Q 110)